ml Stock Suspension	Diluted to	NTU Value
5 ml of 4000-NTU	200 ml	100
20 ml of 100-NTU	200 ml	10
15 ml of 10-NTU	200 ml	0.75

Correcting For Turbidity of Dilution Water

There will always be a residual turbidity even in the purest water. At the 1-NTU level, this can have a significant effect on the value of the Formazin standard. The 0.75-NTU Formazin standard for the 0-1 range can be corrected for the turbidity of the dilution water by the following procedure:

1. Make a nominal 0.75-NTU Formazin standard by diluting 15 ml of 10-NTU Formazin to 200 ml with turbidity-free water.
2. Standardize the turbidimeter at 0.75 NTU on the 1.0 range.
3. Measure and record the turbidity of the dilution water used in preparing the 0.75-NTU standard. It must be less than 0.25 NTU or the combined turbidity of the Formazin stock and dilution water will exceed the top of the 1.0 range.
4. Calculate the actual NTU value of the nominal 0.75-NTU standard using the following equation:

$$T = (A/B)(T_s) + (1-A/B)(T_w)$$

where A = volume of stock solution
B = total diluted volume
T_s = turbidity of stock solution
T_w = turbidity of dilution water

For example, if the dilution water used in Step 1 had a turbidity of 0.15 NTU, then

$A = 15$
$B = 200$
$T_s = 10$
$T_w = 0.15$

The corrected value of the nominal 0.75-NTU standard would be:

$T = (15/200)(10) + (1 - 15/200)(0.15)$
$T = 0.75 + 0.14$
$T = 0.89$ NTU

5. Standardize the turbidimeter at the corrected value (0.89 NTU) in the 0-1 range.

Preparing Turbidity Standards with Digital Titrator

The Hach Digital Titrator can be used to prepare convenient and precise turbidity standards as an alternate method for checking the accuracy of the turbidimeter or the secondary turbidity standards supplied with the instrument. A digital titrator Formazin cartridge, rated at 4000 NTU, is available that can be used to make suitable dilutions for checking each range of the turbidimeter.In the following procedures, dilutions rated at 100 NTU, 10 NTU, and 1 NTU are prepared.

1. Prepare approximately 800 ml turbidity-free water by filtering demineralized water through a 0.45-micron membrane filter.
2. Shake the 4000-NTU Formazin cartridge vigorously to mix the Formazin suspension. Shake for 1 minute.
3. If using the titrator in the hand-held position, attach a clean, straight-stem delivery tube to the cartridge. Twist the cartridge onto the titrator body. If the titrator is to be used on a laboratory stand, use a clean, 90-degree delivery tube.
4. Flush the delivery tube by turning the coarse delivery knob to eject a few drops of Formazin. Reset the counter to zero and wipe the tip.
5. Select the appropriate standard concentration from the options below and prepare the dilution as described. Then fill a clean sample cell to the mark with the standard and use it to check the accuracy of the turbidimeter or secondary standard.

   100-NTU Standard—Dispense 1000 digits of Formazin into a clean, Class A, 50.0-ml volumetric flask. Dilute to the mark with turbidity-free water and mix well.

   10-NTU Standard—Dispense 100 digits of Formazin into a clean, Class A, 50.0-ml volumetric flask. Dilute to the mark with turbidity-free water and mix well.

   1-NTU Standard—**NOTE:** There will be a residual amount of turbidity in even the purest water used to make Formazin dilutions. At the 1 NTU level this can significantly affect the value of the Formazin standard, causing a positive error. The following procedure corrects for the turbidity of the dilution water when making a 1 NTU Formazin standard in a 500.0-ml, Class A volumetric flask.

   a. Standardize the turbidimeter with a secondary standard on a range appropriate for the measurement of the dilution water, usually 0-1 NTU range.

   b. Measure and record the turbidity of the dilution water to be used in making the 1 NTU Formazin standard.

   c. Calculate the number of digits necessary to dispense the proper amount of Formazin

into a 500.0-ml, Class A volumetric flask for a 1 NTU Formazin standard:

DIGITS = $100\,(1 - T_w)$

where T_w is the turbidity of the dilution water.

d. Dispense the calculated number of digits into a 500.0-ml volumetric flask. Slowly turn the fine delivery knob until the proper number of digits is reached. Dilute with dilution water to the 500.0-ml mark and mix well.

NOTE: The following formula may be used to determine the correct number of digits necessary to dispense Formazin for a standard of any value:

DIGITS = $(0.2)(V)(T_D - T_w)$

where T_D = desired turbidity of Formazin standard

T_w = turbidity of dilution water. Term may be dropped if it is 1% or less than T_D

V = volume of flask in ml

Example 1: One liter of a 0.5 NTU Formazin standard is desired. It is found that the dilution water has a turbidity of 0.05 NTU. Since the dilution water turbidity is 10% of the desired standard, the dilution water correction must be made.

The number of digits of Formazin is equal to:

DIGITS = $(0.2)(1000.0)(0.5 - 0.05) = 90$

Thus, 90 digits of Formazin dispensed in a 1000.0-ml, Class A volumetric flask and diluted to volume with 0.05 NTU water will give a 0.5 NTU Formazin standard.

The size of the volumetric flask should be chosen so that the number of digits calculated is approximately 100 or more.

Range Calibration Check

Each range is calibrated at the factory but should be checked from time to time against fresh Formazin turbidity standard dilutions. *Refer to the Calibration Standards paragraph for instructions for preparing standards.* Three trimmer potentiometers on the amplifier circuit board provide an adjustment for each range. Check each range *as described in the following procedure* and make the appropriate adjustments when necessary, using the procedures *described in Range Calibration.*

1. With the instrument turned off, check the mechanical zero adjustment on the meter face. Adjust for a zero reading if necessary.
2. Turn the instrument on and perform a battery check. Charge the battery pack if the meter indicates below the BATTERY CHECK area.
3. Place the focusing template into the cell holder, press the 1.0 range switch, and adjust the ZERO control to obtain a zero NTU reading.
4. Remove the focusing template and insert a 0.75-NTU turbidity standard. Adjust the SPAN control for a corrected 0.75-NTU reading.
5. Remove the 0.75-NTU standard and replace it with a 10-NTU standard. Press the 10 range switch. The meter should indicate 10 (±0.2) NTU. If it does not, the 10 range potentiometer needs adjustment *as described in the Range Calibration procedure.* Adjust the SPAN control for a reading of exactly 10 NTU.
6. Remove the 10-NTU standard and replace it with the cell riser and 100-NTU standard. Press the 100 range switch. The meter should indicate 100 (±2) NTU. If it does not, the 100 range potentiometer needs adjustment *as described in the Range Calibration procedure.*
7. Remove the 100-NTU standard and cell riser and insert the 10-NTU standard. Press the 10-NTU range switch. Adjust the SPAN control for a reading of exactly 10 NTU.
8. Remove the 10-NTU standard and replace it with a 0.75-NTU standard. Press the 1.0 range switch. The meter should indicate the corrected value for the 0.75-NTU standard (±0.02). If it does not, the 1.0 range potentiometer needs adjustment *as described in the Range Calibration procedure.*

Range Calibration

In the event the range adjustment potentiometers on the amplifier circuit board require adjustment, remove the instrument from its case and proceed as follows:

1. With the instrument turned off, check the meter's mechanical zero adjustment. Adjust for a zero reading if necessary.
2. Turn on power and perform a battery check. Charge the battery pack if the meter indicates below the BATTERY CHECK area.
3. Place the focusing template into the cell holder, press the 1.0 range switch and adjust the SPAN control fully counterclockwise.
4. Adjust the ZERO control clockwise to obtain a 0.05-NTU reading on the 1.0 scale.

5. Adjust the SPAN control clockwise to obtain a reading of 0.15-NTU on the 1.0 scale. Do not alter the SPAN control setting for the remainder of this procedure.
6. Press the 100 range switch and adjust the ZERO control for a zero reading.
7. Remove the focusing template and insert the cell riser and 100-NTU Formazin turbidity standard. Cover the standard with the light shield and allow the meter to stabilize. Adjust the 100 range adjustment potentiometer to obtain a full-scale reading. *See Figure 6.*
8. Remove the 100-NTU standard and cell riser and insert the focusing template into the cell holder.
9. Press the 10 range switch and adjust the ZERO control for a zero reading.
10. Remove the focusing template and substitute the 10-NTU Formazin standard. Cover with the light shield and allow the meter to stabilize. Adjust the 10 range adjustment potentiometer to obtain a full-scale reading.
11. Remove the 10-NTU standard and insert the focusing template.
12. Press the 1.0 range switch and adjust the ZERO control for a zero reading.
13. Remove the focusing template and insert the 0.75-NTU Formazin turbidity standard. Cover with the light shield and allow the meter to stabilize. Adjust the 1.0 range adjustment potentiometer to obtain a reading equal to the corrected NTU value determined when adding the turbidity of the dilution water to the nominal value of the standard. *Refer to "Correcting For Turbidity of Dilution Water."*

Cleaning

Other than the sample cells themselves, the only optical surfaces that require occasional cleaning are those of the lens. The lens assembly is located in the bottom of the cell holder assembly and is accessible from the underside of the panel. A plastic thumbscrew holds the lens assembly in the cell holder. To remove the lens for cleaning, loosen the thumbscrew and lower the lens assembly out of the cell holder. *See Figure 5.* The lens surfaces can then be wiped clean, or if desired, the lens can be removed from its holder and cleaned more thoroughly. Use a cloth or tissue that will not leave an oil film on the glass.

When replacing the lens assembly, place it in the cell holder with the screw heads showing. The instrument must now be focused *as described in the Lamp Alignment and Focusing procedure.*

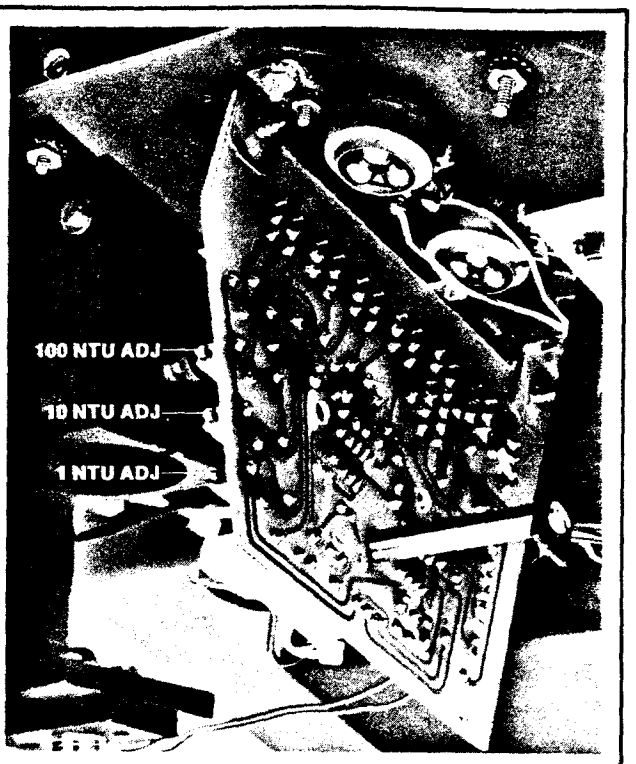

FIGURE 6 RANGE ADJUSTMENTS

Battery Replacement

Five size D batteries supply operating power in the Model 16800 Portalab Turbidimeter. Replace the battery pack as follows:

1. Remove the four mounting screws from the front panel.
2. Lift the panel from the case and place it face down on a protective mat.
3. Remove the four mounting nuts and washers that hold the battery cover to the panel. *See Figure 7.*
4. Remove the battery pack from the cover and disconnect the two wires from the battery terminals.
5. Connect the new battery pack to the two wires, red to the positive terminal and black to the negative terminal.
6. Perform a battery check. If the proper meter deflection is obtained, reassemble the instrument. If not, charge the battery pack and recheck the batteries.

Lamp Replacement

1. Remove the four mounting screws from the front panel.

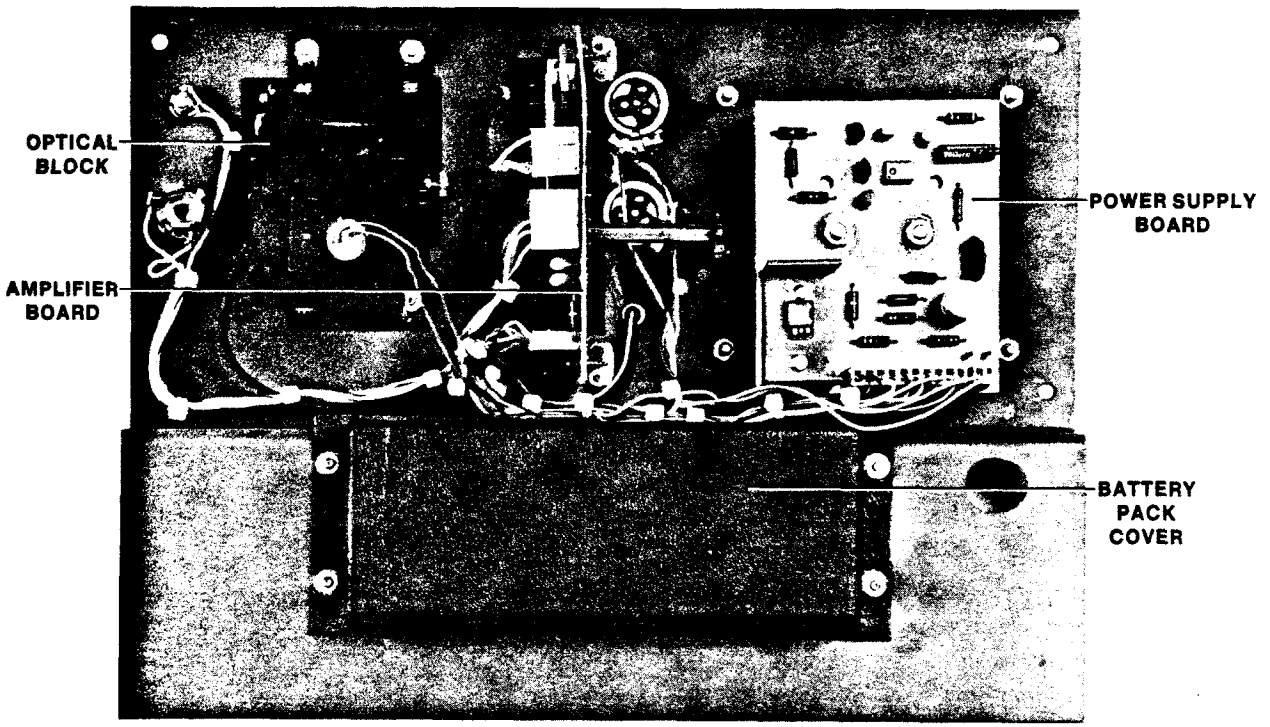

FIGURE 7 **CONTROL PANEL, REAR VIEW**

2. Lift the panel from the case and place it face up on a protective mat.
3. Unplug the lamp connector from the power supply circuit board. *See Figure 7.*
4. Remove the two lamp adjusting screws. The lamp and lamp holder are a single assembly and must be replaced as a unit.
5. Install the new lamp assembly and plug in the lamp connector.
6. Check the lamp position and focus using the focusing template *as described in the Lamp Alignment and Focusing procedure.*
7. Reinstall the panel in the instrument case and restandardize the instrument.

Photocell Replacement

1. Remove the two screws and washers in the cell holder cover and lift off the cover. *See Figure 8.*
2. Unsolder the two coaxial cable connections from the photocell circuit board.
3. Remove the four screws and washers that secure the photocell circuit board to the side of the cell holder. Remove the photocell circuit board assembly.
4. Install the replacement photocell circuit board assembly on the cell holder and solder the coaxial cable leads to the terminals. Note that one of the terminals is marked for the shield connection.
5. Replace the cell holder cover and restandardize the instrument.

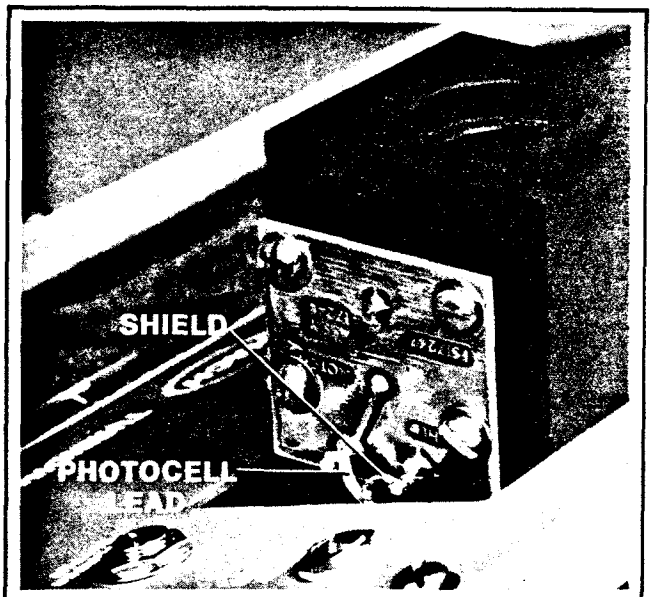

FIGURE 8 PHOTOCELL CONNECTIONS

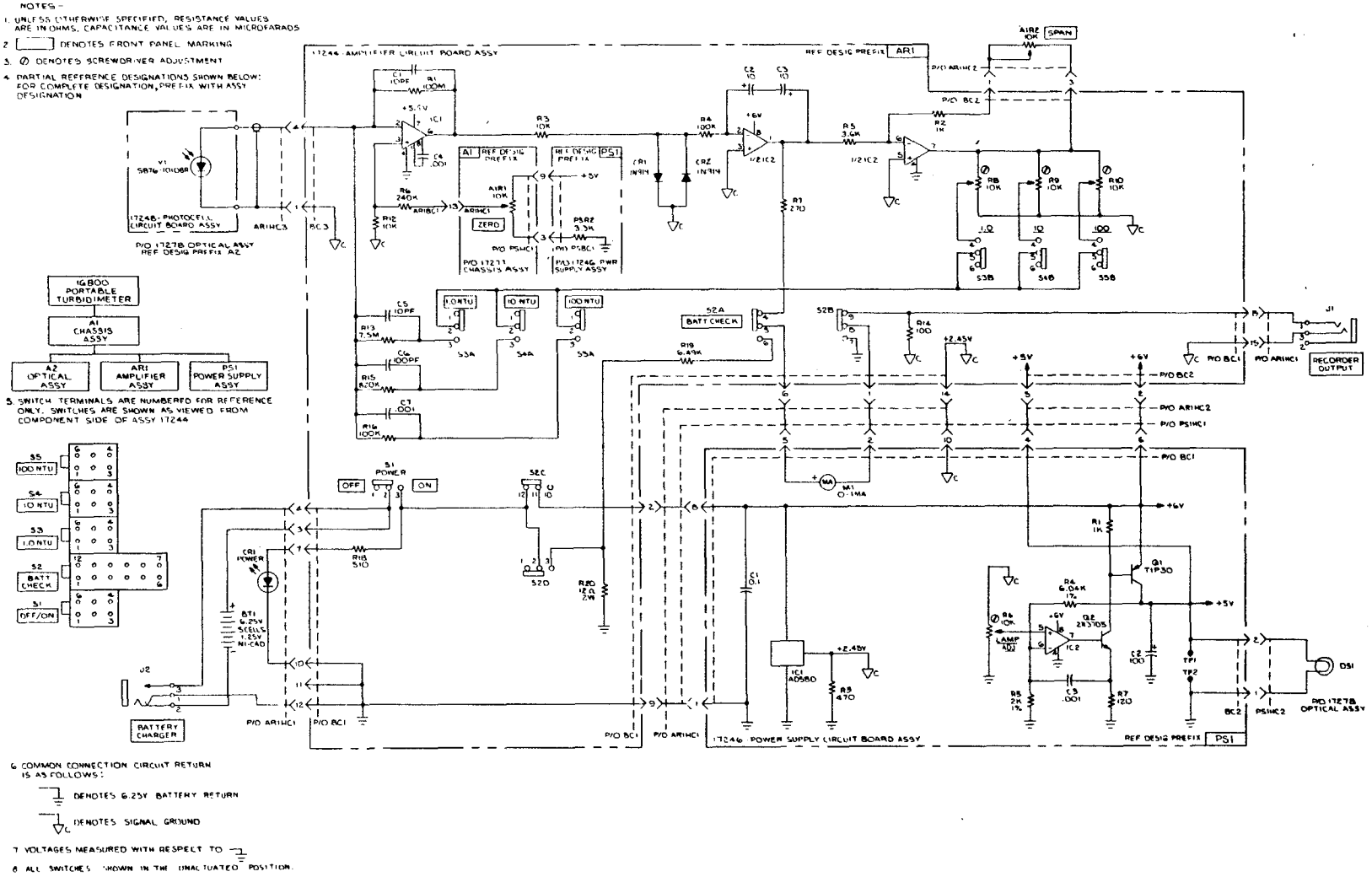

FIGURE 9 **SCHEMATIC**

REPLACEMENT PARTS AND ACCESSORIES

Ref	Description	Cat. No.
	Battery Charger, 115V, 60 Hz/230 V, 50-60 Hz	17058-00
BT1	Battery Pack	16968-00
	Beaker, poly, 50 ml	1080-41
	Bottle, wash, 4 oz	620-14
	Case, Portalab Turbidimeter	17276-00
	Cell Riser	17241-00
AR1	Circuit Board, amplifier	17244-00
PS1	Circuit Board, power supply	17246-00
	Foam Insert, case	17282-00
	Focusing Template	17295-00
	Instruction Manual	40298-00
DS1	Lamp Assembly	17238-00
	Lens Assembly	17281-00
	Light Shield	17239-00
M1	Meter, with scale	17292-00
V1	Photocell Circuit Board Assembly	17248-00
	Plug, recorder input, 3-conductor	16084-00
R1, R2	Potentiometer, 10 turn, 10K (span and zero adj)	12365-18
	Silicone Oil, ½-oz SCDB	1269-36
	Standardization Kit	22958-00
	Stray Light Standard	40263-04
	Turbidity Standard, 90 NTU	22957-03
	Turbidity Standard, 9 NTU	22957-02
	Turbidity Standard, 0.9 NTU	22957-01

OPTIONAL ACCESSORIES AND APPARATUS

Digital Titrator	16900-01
Filters, membrane, 0.45 micron	13530-00
Filter Holder	13529-00
Filter Pump	2131-00
Flask, filtering, 1000 ml	546-53
Flask, volumetric, class A, 50 ml	14574-41
Flask, volumetric, class A, 500 ml	14574-49
Sample Cell Kit, set of 4	21002-00
Stopper, filter flask, no. 7, pkg of 6	2119-07
Tubing, rubber	560-19
Tweezers, plastic	14282-00

OPTIONAL REAGENTS

Formazin Cartridge, Digital Titrator, 4000 NTU	2461-01
Formazin Stock Solution, pint, 4000 NTU	2461-11
Hexamethylaminetetramine, 500 g	1878-34
Hydrazine Sulfate, 100 g	742-26
Triton X-100 Solution, 4-oz DB	14096-13

REPAIR SERVICE

If you wish to return the instrument for factory service, please write or call the nearest Hach Factory Service Center first for shipping instructions. Without prior arrangement, charges for "Collect" shipments are customarily rebilled to the customer.

FACTORY SERVICE CENTERS

Hach Company
100 Dayton Ave.
P.O. Box 907
Ames, IA 50010
(515) 232-2533

Hach Company
57th St., Lindbergh Pkwy.
P.O. Box 389
Loveland, CO 80539
(303) 669-3050

Hach Company
13003 Southwest Freeway
Suite 150
Stafford, TX 77477
(713) 240-8066

Hach Company
7854 Browning Road
Pennsauken, NJ 08109
(609) 662-0034

Hach Company
46711 Fremont Blvd.
Fremont, CA 94538
(415) 651-1120

Hach Company
2046-I West Park Place
Stone Mountain, GA 30087
(404) 498-0511

Hach Company
1901 Production Road
Fort Wayne, IN 46808
(219) 482-3015

If you are located in Canada, Latin America, the Caribbean, the Far East or the Pacific Basin, please contact Hach Company, World Headquarters, P.O. Box 389, Loveland, Colorado U.S.A. 80539. Telephone (303) 669-3050, TWX (Telex) 910-930-9038. Customers located in Europe, the Middle East or Near East, or in Africa, please contact Hach Europe, S.A./N.V., B.P. 51, 5000 Namur 1, Belgium. Telephone (081) 44.53.81, Telex 846-59027.

WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to (1) repair, (2) replacement with equivalent Hach equipment, or (3) an appropriate credit adjustment not to exceed the original sales price of equipment returned to the Seller, provided that:

a. Buyer promptly notifies Seller in writing on discovery of the defects, stating where applicable, the product type and serial numbers and fully describing the circumstances giving rise to the claim. Seller must receive such notification within the applicable warranty period in order for this warranty to apply.

b. On receipt of written instructions from Seller, Buyer returns the equipment as instructed with transportation charges prepaid by the Buyer; and

c. Seller's examination of such equipment discloses to its satisfaction that the defects have not resulted from any negligence, misuse, improper installation, accident or unauthorized repair or alteration by the Buyer. Seller's determination of the cause and nature of the failure of the equipment shall be final.

This warranty does not include limited life electrical components which deteriorate with age such as vacuum tubes, batteries, lamps, photocells, electrodes, etc. In the case of equipment and accessories not manufactured by the Seller, but furnished with equipment of Seller's manufacture, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and shall be in lieu of and exclude all other warranties, expressed or implied, including, but not limited to, any implied warranty of merchantability or fitness. The foregoing shall constitute the sole and exclusive remedy of Buyer and the sole and exclusive liability of Seller, whether Buyer's claims shall be for breach of warranty or negligence. Seller neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the sale of the equipment. In no event shall Seller be liable for special, incidental, or consequential damages.

If Seller finds that Buyer has returned the equipment without cause, Seller shall notify Buyer and return the equipment at Buyer's expense; in addition, Seller may, at its sole discretion, impose a charge for testing and examination of any equipment so returned.

SYSTEMS FOR ANALYSIS

AUTOMATIC ANALYZERS FOR

- ALKALINITY
- CALCIUM IN BRINE
- CHELANT
- CHLORINE
- CHLORINE DIOXIDE
- CONDUCTIVITY
- COPPER
- HARDNESS
- HEXAVALENT CHROMIUM
- HYDRAZINE
- IRON
- MANGANESE [7]
- OZONE
- pH
- PHOSPHATE
- POTASSIUM PERMANGANATE
- SILICA

TURBIDIMETERS

pH AND CONDUCTIVITY METERS

PORTABLE INSTRUMENTS

PORTABLE TEST KITS

LABORATORY APPARATUS

REAGENTS

HACH

HACH COMPANY
P.O. Box 389, Loveland, Colorado 80539 U.S.A.
303-669-3050 TWX: 910-930-9038

HACH EUROPE S.A./N.V.
B.P. 51, 5000 Namur 1, Belgium
081/44.53.81 · Telex: 846-59027

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APPENDIX G

OPERATIONS MANUAL FOR ACQUISTAR DL-1 DATA LOGGER

Procedure for setting the acquisition parameters in the data logger:

- Install a fully charged battery in the data logger and firmly screw the top shut on the unit.
- Connect the data logger to the RS-232 serial port on an IBM compatable computer, and run the Terra3 program.
- Select "Terminal Emulator" on the Main Menu and "Terminal Mode" on the Terracom sub-menu. "Wake" the data logger by holding down the **C** or **<shift>c** keys for about 30 seconds. When the data logger becomes active, a square prompt will appear, then a bar menu across the top of the screen. If this does not occur, refer to the procedures for loading acquisition software into the data logger memory.
- To set the data acquisition parameters, enter **1** for "1-Setup". The time and date may be set by entering **1** for "1-Time" and following the instructions. Follow the prescribed format. Set the frequency of measurements by entering **2** for "2-Scan Interval", and select **1** for "1-Single Int." (this is currently used at JPL) and follow the instructions given. The number of readings between time stamps may be set by entering **3** for "3-Logs/Tstamp" and following instructions. The channel information may be set by entering **4** for "4-Channel Info." and following instructions.

The data acquistion program, PGM3, may be loaded into the data logger RAM using the following procedures:

- Enter **run**, if no menu bar appears and the response is **OK** then PGM3 may be loaded into memory from the EPROM in the data logger.
- To load PGM3 from the EPROM, enter **load"PGM3**, if the response is **OK**, enter **run** and the menu should appear. If loading PGM3 from the EPROM is unsucessful, it may be loaded from discette.
- To load PGM3 from discette, enter **new** at the **>** prompt, then enter **<esc>** to return to the Terracom sub-menu.

- When in the Terracom sub-menu, select "Install Program". At the prompt, enter the path and PGM3 (eg: **b:PGM3**). When the program has been verified, press any key to continue and the program will be loaded into the data logger. When this operation is complete, return to the Terracom sub-menu and select "Terminal Mode".
- Repeat the above procedures as applicable to wake the data logger.

Procedure for affixing anchoring device to transducer cable in 4-inch monitoring wells:

- In the wells with 4-inch casing, a specially built wire net with a loop at the top is used. The net is wrapped around the cable and the edges of the net are "sewn" together using a removable steel pin. It is important that the net is tightly wrapped around the cable and the pin is inserted through all the loops along the edges of the net to ensure that the cable will not slip through. The pin should be inserted through loops from alternating edges of the net.
- When the wire net has been affixed to the cable secure the net to the cable using a plastic tie and mark the cable at the bottom of the net.
- The loop at the top of the anchoring device is then connected to the eye hook at the bottom of the data logger using a quick chain connector. A short length of chain may be incorported into this arrangement. If a dedicated sampling system has been installed in the well, the eye hook at the bottom of the sanitary seal may be used.

Procedure for affixing a cross-piece anchoring device:

- In well MH-01, the casing is too large to use the same type of anchor as that used in the 4-inch wells. Here, a short length of 1 1/2-inch PVC pipe with a 1/4-inch dowel cross piece is used. The pipe has been slotted so that it can be laid on the top of the well casing without rolling. A hole has been drilled through the sides of the pipe and the dowel inserted to provide a cross piece to further prevent rolling of the pipe.
- Tightly wrap the cable around the center of the ancoring device in a cross-wise fashion and secure the cable to the anchor using duct tape to prevent unravelling.

There should be no slack in the portion of the cable wrapped around the anchoring device.

Procedure for storage of excess cable in wells where wire net anchoring device is used and the data logger is set in the well casing:

- The data logger is installed in the well casing in wells where the traffic box or monument cover is too small to accommodate the data logger. Since the cable may be crimped or cut if it is placed between the well casing and data logger, it is necessary to store the excess cable in the well.
- Storage of the excess cable inside the well casing is accomplished by stretching out the excess cable into a long loop and bundling the cable by doubling it over several times. Take care not to disturb the anchor holding the portion of the cable in the well. The result should be a 5 to 6 foot long bundle of cable with the length of cable leading to the desiccant chamber and that leading to the anchoring device coming off the same end of the bundle.
- Bind the doubled over cable at either end of the bundle using plastic ties. Do not kink the cable in the loops at the ends of the bundle.
- Slip the bundle into the well casing.

Procedure for storage of excess cable in wells where thew data logger is not set in the well casing:

- The data logger is not installed in the well casing in wells where the cross piece anchoring device is used and where a dedicated sampling device has been installed.
- The excess cable between the bottom of the data logger and the anchoring device may be stored by carefully wrapping it around the outside of the well casing, inside the traffic box or monument cover. Avoid any twisting or kinking of the cable.

AquiStar™ DL-1/DL-1A

Operator's Manual

July 3, 1990

WARNING

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the operations manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference for operating the equipment in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the owner, at his or her own expense, will be required to take whatever measures may be necessary to correct the interference.

CONTENTS

PREFACE

Congratulations on the purchase of your new single-channel AquiStar DL-1 or DL-1A. This manual has been provided to assist you in the installation and operation of the unit. To insure maximum use of your time in the field and minimization of your efforts, we recommend that you thoroughly familiarize yourself with this manual and the operating software prior to installing the equipment in the field.

Chapters I through VIII of this manual contain all the information required for normal operation of the AquiStar. Although the operating software is completely menu-driven and prompts the user for appropriate information, there may be some situations which require the use of certain *BASIC* (a standard programming language) commands that relate to reloading or reinstalling a program, saving a program to disc, or finding out which program is burned onto *EPROM* (a read-only memory in the data logger) in your particular unit. For this reason, we have included in the Appendix section of this manual a brief list of essential BASIC commands and explanations for their use. Advanced techniques, such as real-time data printout and alternative water level referencing are discussed in the Appendix section as well.

NOTATIONAL CONVENTIONS

In this manual, certain typestyles have been used for specific purposes that are explained below:

Typestyle	Purpose
bold	Used for menus and menu options, as well as commands, arguments, and literal portions of syntax that must appear exactly as shown.
italics	Used for variables or placeholders that represent text that you should type. Italics are also used for emphasis or to introduce new terms.
<SMALL CAPS>	Small caps framed by the characters < > are used for keys and key sequences. When keys are to be pressed together, they will be shown joined by a plus (+) sign.

Keyboard entries mentioned in this manual should be typed exactly in the form shown, including spaces, etc. In some instances, keyboard entries are shown in quotation marks to differentiate them from specific commands or menu items. Quotation marks should never be typed, *unless specifically instructed otherwise.*

As a general rule, computers are not case-sensitive and will accept input in upper or lower case characters, even though screen output may sometimes appear in all-capital letters. To avoid confusion, this manual has eliminated the use of all-capital letters, except for acronymns and proper names. In the few instances, where input in all-capital letters is required, you will be specifically instructed to this effect.

You will note that the screens and menus contained in your utilities/communication software refer to *Terra8*. This is explained by the fact that the software package was originally written for this product. However, the program applies in identical fashion to the AquiStar DL-1 and DL-1A.

I INTRODUCTION

The AquiStar DL-1/DL-1A is a third-generation single-channel data acquisition unit designed to scan various transducers and log data while unattended for long periods of time. It runs under the control of a BASIC language interpreter (*TERRABASIC*) that stores the collected data in non-volatile *RAM* (random-access memory) memory for subsequent retrieval by the user via a serial communications link (RS232C). By attaching a printer to the parallel port of the host computer, the capabilities of the AquiStar can be expanded to include simultaneous printer output during data acquisition.

The AquiStar incorporates a unique *timeout* feature, which conserves battery power by automatically switching the data logger from the active *wake mode* into a low-power *sleep mode* whenever more than three (3) minutes pass without input from the keyboard. During data acquisition, the unit also switches to sleep mode between logs, provided that logging intervals are greater than three (3) seconds.

For the convenience of the inexperienced user, a standard application program, *PGM3*, is provided, which fully covers the needs of both linear and variable-rate monitoring schemes. User-friendly menus and prompts make this program easy to learn, while affording the user the flexibility to adapt the program to his or her particular needs.

For those who have complex types of sampling to do or who have specific ideas about how transducer data should be treated, the AquiStar is fully programmable. The *TERRABASIC* interpreter with its specialized data collection functions and statements provides both a versatile and familiar programming environment, with which experienced BASIC programmers should feel comfortable. A technical reference manual is available for those who wish to utilize the advanced programming capabilities of the AquiStar. If you are interested in obtaining this manual, please contact your sales representative.

The hardware and software described in this manual refer to a standard AquiStar DL-1 or DL-1A, unless otherwise noted. Future versions of the AquiStar may contain slight variations in hardware and/or software. Should these variations affect operation of the unit, appropriate instructions will be made available in a supplement to this manual.

II HARDWARE AND SOFTWARE REQUIREMENTS

Before you start using your new AquiStar, you need to insure that you have the right hardware and software to conduct your monitoring routines.

HARDWARE

The following items are required to carry out your monitoring tasks:

- An AquiStar DL-1 or DL-1A data logger.
- Any IBM or compatible laptop computer running on MS-DOS 2.1 or greater, with serial port, Hercules, EGA, CGA or VGA graphics adaptor, and a minimum of 384K RAM. The laptop computer is essential for field operations; of course a desktop unit may be used for practice purposes or to set up and configure your data logger for later monitoring. It might prove easier to accomplish these tasks in the comfort of your office.
- A screened RS232C (serial) cable with appropriate connectors. Verify that your cable is a straight-through serial cable and *not a null modem cable*!

  Note In order to comply with FCC regulations for a Class A computing device, you must use a screened RS232 cable. If the cable was purchased with the AquiStar, it will be suitably screened; if it was obtained separately, you are advised to check for the presence of a cable screen.
- A sensor designed for the particular parameter you wish to monitor (pressure, temperature, conductivity). Be aware that the sensor must be compatible with the signal conditioning and excitation voltage of the AquiStar, regardless of the parameters you wish to measure.
- *Optional*: A parallel printer to allow for simultaneous printer output during data acquisition.

SOFTWARE

In addition to the above hardware, the following software is necessary for the operation of your data logger:

- PGM3, a standard application program written for use with the AuiStar DL-1 or DL-1A. In conjucntion with Terrasys 3.0, this program allows you to configure your data logger for its particular monitoring tasks.
- Terrasys 3.0, a utilities and communications package, which enables you to communicate with your data logger and allows you to view and manipulate the data, as well as convert the data to printer and spreadsheet compatible files.

CONNECTING THE HARDWARE

TERMINAL

In order to communicate with the AquiStar, you need a *terminal device* which provides a screen and a keyboard. Therefore, your first step is to connect your computer with the data logger via the RS232 cable so that your computer can act as the terminal device. Attach the serial port connector of the cable to the serial port (COM1 or COM2) of your computer and connect the other end of the cable to the RS232 port of the AquiStar.

You are now ready to communicate with the AquiStar via the Terrasys 3.0 *terminal emulation program* (a program that allows your computer to act as a terminal and be controlled by the AquiStar).

SENSOR

If you purchase your sensor with the AquiStar, the proper connections are already in place, and the sensor is compatible with the signal conditioning and excitation voltage of the AquiStar. For those who wish to use a sensor from a different manufacturer, the configuration of the sensor connector on the data logger is listed below.

Pin A - Not used
Pin B - Excitation
Pin C - Ground - Not used
Pin D - Signal return
Pin E - Not used
Pin F - Cable shield

The cable shield should be connected at the AquiStar and insulated from the sensor body.

For details regarding the wire designations of your sensor cable, contact your sensor manufacturer.

PRINTER (OPTIONAL)

If you wish to print out data while it is being collected, you can do so by connecting a parallel printer to the LPT1 port of your computer. See Appendix B for details on how to print data during acquisition.

III GETTING STARTED

The information contained in this chapter provides an overview of the operating software that will enable you to start using your AquiStar. It will give you a chance to check and/or change the set-up of the unit and become familiar with some of the basic functions of both PGM3 and Terrasys 3.0. The "Quickstart" section later in this chapter provides an example of a standard monitoring routine and gives you step-by-step instructions on how to set up your AquiStar for this task, including the retrieval of data following completion of a monitoring scheme.

For a complete description on how to work with PGM3 and Terrasys 3.0, please read Chapters V and VI.

THE INTERACTION BETWEEN PGM3 AND TERRASYS 3.0

PGM3 is the BASIC interpreter that controls the logging actions of your AquiStar. It is completely menu-driven, which means that it allows you to choose an item from a variety of options. Each menu option is preceded by a number. To make a selection, simply type the appropriate number and press <ENTER>.

To set the AquiStar up for the particular monitoring task you wish to accomplish, you need to communicate with the data logger via your computer using the communications/utilities software, Terrasys 3.0. While Terrasys 3.0 is menu-based as well, the process for selecting a menu option is slightly different from the one used in PGM3. You place the highlight on the desired item and press <ENTER>, or you simply type the first letter of the desired item and press <ENTER>. Before you can communicate with your AquiStar, you first have to insure that the serial port communications parameters of your computer are compatible with those of the AquiStar. To verify and/or change these parameters, follow these steps:

1. After you have connected the AquiStar to your computer via the RS232 cable, turn on your computer and insert the Terrasys 3.0 diskette into Drive A (if you have installed Terrasys 3.0 on a hard drive, switch to the subdirectory that contains Terrasys).

2. Load Terrasys 3.0 into your computer's *workspace* by typing **Terra3** at the DOS prompt, followed by <ENTER> (on some keyboards, the <ENTER> key will be named <RETURN>; both keys have the same function). The screen will now display the Terrasys 3.0 main menu.

3. Select the **Terminal Emulator** menu option. Your screen will now display the **Terracom** menu.

4. Select the menu option **Change Baud Rate.** A new screen will appear displaying the serial port communications parameters of your computer. For each parameter, a number of values will be shown, and the current setting for each parameter will be highlighted. A blinking highlight indicates the line in which you are presently working. If you wish to accept the current value, move the highlight to the next parameter by using the <DOWN> arrow key; to change the current value, move the highlight to the desired value by using the <RIGHT> or <LEFT> arrow key and continue down through the list of displayed parameters, until they are set to the following:

Port:	COM1 or COM2 (select the COM port on your computer that you connected to the AquiStar)
Baud Rate:	1200
Parity:	None
Word Length:	8
Stop Bits:	1
Xon/Xoff:	Enabled (or On)
Echo:	Off

When all values are set correctly, press <ENTER>. The program will return to the **Terracom** menu. You are now ready to communicate with your data logger.

LOADING PGM3

In order to control the logging routine of your AquiStar, PGM3 must be in the workspace (RAM) of your data logger. When you purchase an AquiStar DL-1 or DL-1A, PGM3 is already preinstalled in RAM. A permanent copy of PGM3 resides in the EPROM of your data logger. PGM3 can also be *downloaded* from diskette via the **Install** option in the **Terracom** menu. The following circumstances may require you to load PGM3 into the workspace:

- A different program resides in the workspace of your AquiStar.
- You pressed the Reset button on the circuit board.
- You typed the **New** command at the TERRABASIC prompt.
- Both the main battery and the back-up lithium battery fail.

The following paragraphs describe how to access PGM3 for the first time.

> **Note** When working with PGM3, it is important to remember the automatic timeout feature of this program. When more than 3 minutes pass without input from the keyboard, the logger will revert to the sleep mode to conserve the battery. When this occurs, simply "wake" the logger by holding down the <SHIFT>+<C> keys until you see a response on the screen.

PGM3 ALREADY IN RAM

1. Load Terrasys 3.0 as described in the previous section, and select **Terminal Emulator** from the main menu.
2. From the **Terracom** menu, select the **Terminal Mode** option. The upper right hand corner of your screen will indicate "Terminal Mode".

Note While you are working in terminal mode, everything that appears on your screen is controlled by the data logger and not your computer.

3. Hold down the "C" key (must be capital letter!) on your keyboard to wake the data logger. Release the key as soon as you see a string of "C" characters appear on your screen.

4. Press <ENTER>. You will either see a prompt (">") or a menu. If a menu appears, nothing further is required.

5. If you see a prompt, type **Run** and press <ENTER>. Your screen will now show the current configuration of the AquiStar, as well as the main PGM3 menu along the bottom.

```
TIME:                    04/20 08:23:03.57
SCAN INTERVAL:           00/00 00:00:10

LOGS/TIMESTAMP:          1

--CHANNEL INFO--
SENSOR DESCRIPT:         CURRENT
DISPLAY UNITS:           mA
CONVERSION MULT:         4
OFFSET:                  0 mA
WARM-UP  (mS):           100

1-Setup     2-Acquisition     3-Data     4-Monitor   5-Sleep?
```

Figure 3.1 PGM3 Main Menu Screen

LOADING PGM3 FROM EPROM

If after typing the **Run** command in step 5 above, you receive an "OK" message but no menu or set-up information, it means that PGM3 is not present in RAM and will have to be installed. To install PGM3 from EPROM:

1. At the prompt, type **Load"PGM3"** (including quotation marks - PGM3 must be capitalized!) and press <ENTER>. If you receive the message "Not Fnd", you either entered the command incorrectly and will have to retype it, or PGM3 is not in the EPROM of your data logger and will have to be loaded from diskette. See the next section for details on how to load PGM3 from diskette. If you receive an "OK" message, the program was loaded successfully and you proceed to step 2.

2. Type **Run** and press <ENTER>. You screen will now show the set-up information and the main PGM3 menu on the bottom.

LOADING PGM3 FROM DISKETTE

If your data logger is an older model, the EPROM most likely will contain PGM2 or even PGM1. You can still work with PGM3 but will have to install it into the workspace from a diskette file. Use the following procedure to install PGM3 from diskette:

1. Load Terrasys 3.0 as previously described and select **Terminal Emulator** from the main menu.

2. From the **Terracom** menu, select the **Terminal Mode** option. Your screen will indicate "Terminal Mode" in the upper right hand corner.

3. At the TERRABASIC prompt (>), type **New** and press <ENTER>; then press the <ESC> key to return to the **Terracom** menu.

4. Select the option **Install Program.** The top of your screen will display the information "Terrabasic File Name —>", followed by the default drive and *path.*

5. Insert the PGM3 diskette into drive A of your computer and type "A:\PGM3.", then press <ENTER>. The source file will be verified, and you will receive a message on your screen advising you of the number of lines in the program (e.g. "102 lines processed").

6. Press any key to begin installation of the program. Your screen will display the program line-by-line as it is being loaded into RAM. When the installation process is complete, your screen will display the following message:

   "Program successfully installed <AnyKey>"

7. Press any key to return to the **Terracom** menu.

   Note Installation of PGM3 from diskette is time consuming, since the program is loaded into RAM one line at a time. Therefore, we recommend that you only use this alternative if PGM3 is not present in the EPROM of your data logger.

You may wish to verify that PGM3 is properly installed. In order to do so, follow these steps:

1. Select **Terminal Mode** from the **Terracom** menu.

2. Wake up the data logger by pressing the <SHIFT>+<C> keys until a number of C characters appear on your screen.

3. Press <ENTER>. Should you see the message "?SN ERR", ignore it and proceed with step 4.

4. At the prompt, type **Run.** If the set-up information and the main PGM3 menu appear on your screen, your program was successfully installed.

QUICKSTART

The following section of this chapter is designed to provide an overview of the most basic functions of PGM3 and Terrasys 3.0. An example of a complete pump test, including the configuration of the data logger and retrieval of the data, will guide you, step-by-step, through the basic tasks involved with a simple, standard type of test. For a complete discussion of all software features and a detailed description of their applications, please refer to Chapter V, Working with PGM3, and Chapter VI, Working with Terrasys 3.0.

EXAMPLE

For the purpose of this example, we have assumed that you plan to carry out an aquifer test requiring water level readings at three variable rates.

In your lab or office, you have connected all appropriate hardware, verified that the serial communications parameters are correct (see "The Interaction Between PGM3 and Terrasys 3.0" earlier in this chapter), and insured that PGM3 is in the RAM of your data logger (see "Loading PGM3" earlier in this chapter for details). Your AquiStar should now be in wake mode, and the main PGM3 menu should be displayed on the screen as follows:

1-Setup 2-Acquisition 3-Data 4-Monitor 5-Sleep?

Configuring the Data Logger

You now have to configure the data logger for the monitoring task ahead. In doing so, you will make various menu choices, each of which will prompt you to enter certain information pertaining to the set-up.

To display the **Setup** menu, type **1**. The screen will show five menu options, each of which contains parts of the set-up information. You start by setting the time:

1. Select **1-Time** by typing **1** and press <ENTER>. The screen will display the current date and time, and the message "OK (Y/N)?" prompts you to confirm or change the current date and time. For the purpose of this example, we assume the time is not correct.

2. Type **N** for "No" and press <ENTER>. The screen will display the message "Enter Month/Day (MM/DD)?".

3. Type the correct month and day in the prescribed format (e.g. "03/13") and press <ENTER>. You will now be prompted to enter the correct time in the format (HH/MM/SS).

4. Type the correct time (e.g. "14/05/30") and press <ENTER>. You must use the 24-hour format to set the time. The screen will now display the new date and time and ask you again to confirm.

5. Type **Y** for "Yes" and press <ENTER>. The screen will return to the **Setup** menu.

The next configuration parameter to be set is the scanning interval you wish to use:

1. Select **2-Scan Interval** from the **Setup** menu by typing **2** and press <ENTER>. The screen will display three menu options: **1-Single Int., 2-Variable Int.**, and **3-Exit.**

2. Your monitoring routine requires variable-rate readings. Therefore, you select **2-Variable Int.** and press <ENTER>. The screen will prompt you to confirm or change the baseline interval (for details on baseline intervals, see Chapter V, Working with PGM3). For the purpose of this example, let's say you accept the given baseline interval.

3. Type **Y** and press <ENTER>. The screen will now display the default variable intervals and the number of scans to be done for each interval. You will be asked if this scanning

set-up is ok. Let's assume your test requires three variable rates. You wish to take 24 logs at 5-second intervals, 20 logs at 15-second intervals, and 120 logs at 60-second intervals. Therefore, at the message "OK (Y/N)?" type **N** and press <ENTER>.

4. The screen will prompt you to indicate how many scanning intervals you want to set up. Type "3" and press <ENTER>.

5. You will now be prompted to indicate the first scanning interval in seconds. Type "5" and press <ENTER>. You will then be asked to provide the number of logs you wish to take at this interval. Type "24" and press <ENTER>.

6. Repeat step 5 to enter the numbers for the second and third scanning intervals (15 and 20 for the second interval; 60 and 120 for the third interval). The program will then return to the **Setup** menu. The logging routine you have set up would take 127 minutes to run, after which time the data logger would stop recording data and go into sleep mode.

   Note When setting up any logging schedule, you need to insure that you will have sufficient memory to carry out the routine. For variable-rate routines, memory fills up at the rate of 10 bytes per log. Another 122 bytes of memory are taken up by the configuration information. For details on how to calculate the time it takes to fill the memory, please see the last section of this chapter.

After returning to the **Setup** menu, check to see if the configuration parameter logs/timestamp is set at 1. This value is mandatory for variable-rate monitoring. If this value does not equal 1, change it as follows:

- Select **3-Logs/Tstamp** from the **Setup** menu by typing **3** and press <ENTER>. You will be prompted to enter a number between 0 and 255. Type "1" and press <ENTER>.

The last configuration parameter to be entered is the channel information. The information you provide here tells the data logger what type of sensor you are using and how to process the signals from this sensor. In order to provide the necessary information:

1. Select **4-Channel Info** from the **Setup** menu by typing **4** and press <ENTER>. The screen will prompt you to accept or change the sensor description. In this example, you are using a 5 psi pressure transducer. Therefore, type "5 psi" and press <ENTER>.

2. The next message will ask you to confirm or change the display units (engineering units). You want to use feet as the display units, therefore, type "ft" and press <ENTER>.

3. You are now prompted to enter the conversion multiplier. For a 5 psi sensor, the conversion multiplier is 2.8875. A detailed discussion on how to calculate your conversion multiplier can be found in Chapter V, Working with PGM3. Type "2.8875" and press <ENTER>.

4. You will be prompted to enter the offset. For an explanation of the offset and some of its other uses, please refer to Chapter V, Working with PGM3. Type "-2.8875" and press <ENTER>.

5. The last item you must provide is the warm-up time. The screen will display a default value of 100 milliseconds, which works well with pressure transducers and is, therefore, acceptable. Press <ENTER> to accept this value.

This concludes the configuration, and your AquiStar is now ready to perform the logging routine. To leave the **Setup** menu, select **5-Exit** by typing **5** and press <ENTER>. The program will return to the main PGM3 menu.

Data Acquisition

The next step in your test is the actual data collection task. It is always started from the **Acquisition** menu, which contains two separate sets of submenus, one for single-rate scanning and one for variable-rate scanning. When you select **2-Acquisition** from the main menu, the program will automatically display the correct menu for the type of logging scheme you have previously set up. In this example, you are sampling at variable rates, therefore, the menu will display the following choices: **1-Variable, 2-Variable with Baseline, 3-Single Scan,** and **4-Exit.** To start logging at the variable rates you have preset:

- Select the option **1-Variable** by typing **1** and press <ENTER>. The logging routine begins immediately after you press the <ENTER> key.

  Note Even though you accepted a default baseline interval during the set-up, you do not have to actually use it in the logging routine. The final decision regarding its use can be made in the **Acquisition** menu. By selecting the option **1-Variable**, you let the data logger know that you do not wish to use the baseline interval.

While logging is in progress, your screen will display information about the readings taken, such as log number, remaining memory, real time, analog channel number (the AquiStar models DL-1 and DL-1A only have one channel) with the reading for that channel in engineering units, and the next calculated wake time.

If you wish to leave the AquiStar in the field unattended, you can disconnect your serial cable at this point, and the AquiStar will continue the logging routine as programmed.

> **Note** Readings taken at intervals shorter than 3 seconds will not be displayed on the screen. You will instead see some graphic characters until the scanning intervals become long enough and the above information is displayed with each log.

If you wish to break into the logging routine and stop it, you can do so as follows:

- Hold down the <SHIFT>+<C> keys, until the main menu appears on the screen. The AquiStar will not go back to logging until you specifically start it again by making the appropriate selection from the **Acquisition** menu.

For complete details regarding the **Acquisition** menu and its various options, please refer to Chapter V, Working with PGM3.

Data Retrieval and Transfer

After your aquifer test is complete and all data has been collected, you will have to transfer this data to your computer's hard disk or onto diskette. This task is performed from the **Data** menu and requires some interaction with the Terrasys 3.0 utility. You may also wish to review

your data before transferring it to your computer. To review the contents of your AquiStar's memory, follow these instructions:

1. Select the option **3-Data** from the main PGM3 menu by typing **3** and press <ENTER>. The screen will display the **Data** menu.

2. Now choose **2-Examine** by typing **2** and press <ENTER>. You will see the message "Start at Log# (1)?".

3. Assuming you want to look at all data records taken, simply press <ENTER>. When the screen prompts you for an ending log number ("End at Log# (End)?"), press <ENTER> again. The logs will scroll across your screen until all records have been displayed. To stop the review before it is finished, simply press the <SPACEBAR>.

Now, the only task left to carry out is to *dump* (transfer) the data to your computer. In order to execute this transfer, take the following steps:

1. From the main PGM3 menu, select **3-Data** by typing **3** and press <ENTER>. Your screen will show the number of logs contained in the memory and the remaining amount of memory, followed by the **Data** menu.

2. Now choose **1-Dump** from the **Data** menu by typing **1** and press <ENTER>. The following message will be displayed: "Press <Esc> to set upload. Press <Enter> when upload mode message appears in the upper right corner of screen?"

   Warning! Before pressing the <ENTER> key at this point, you must designate a file to which the data will be transferred, and insure that your computer is in upload mode to receive the data. Otherwise, no data will be stored in your computer!

3. Press the <ESC> key to exit terminal mode. The screen will now display the **Terracom** menu.

4. Select the menu option **Upload to Disk** by placing the highlight on it and pressing <ENTER>. At the top of your screen, you will see the message "Upload to File —>", followed by the default drive of your computer.

5. Type in the name of your designated data file, including the correct disk drive and directory, if applicable, (a legal filename consists of up to 8 characters, followed by a period and an extension of up to 3 characters), and press <ENTER>.

6. Your screen will display the same message as in step 2 above, but the upper right hand corner of the screen will show that you are now in *upload mode*. Now press the <ENTER> key. The collected data, in hexadecimal format, will be displayed on the screen as it is being transferred to the designated file on your computer.

7. At the end of the data file, the message "Press <ESC> to terminate upload and close file" will appear. Press the <ESC> key as instructed. This will close the *uploaded* file. Upload mode will be terminated, and the program will return to the **Terracom** menu. From there, you can either view the uploaded file in the Terrasys 3.0 utility, or you can switch back to terminal mode to regain communication with your AquiStar.

Note It is highly recommended that you always view your uploaded data file in Terrasys 3.0 before resetting the memory on your data logger.

For a complete discussion of the Terrasys 3.0 program and its features, please see Chapter VI, Working with Terrasys 3.0.

If you wish to reset the memory of your AquiStar, you can do so by following these instructions:

1. From the main PGM3 menu, select **3-Data** by typing **3** and press <ENTER>. The screen will display the number of logs in memory and the remaining amount of memory, followed by the **Data** menu.

2. Now choose the **3-Reset Memory** option by typing **3** and press <ENTER>. The program will delete all data in the memory of your AquiStar. Your screen will display the message "Reset Done" and the current configuration of the data logger and will return to the main PGM3 menu.

   Note Since resetting the memory deletes all collected data, we recommend that you use this option with caution.

For further details on resetting the memory, please refer to Chapter V, Working with PGM3.

This concludes the Quickstart section of this chapter. The following section contains a discussion on how to calculate the time it takes to fill the memory of your data logger.

CALCULATING THE TIME TO FILL DATA MEMORY

In using the AquiStar for different data collection tasks, you will most likely make changes to the configuration section of the PGM3 program. The rate at which the 24 K memory of your AquiStar fills up depends on the particular set-up of each monitoring routine. This section will help you determine the amount of time it takes to fill up the RAM.

Each of the following items requires a certain amount of memory:

- Configuration of the data collection routine (sometimes referred to as "data header block") and channel set-up configuration - 122 bytes
- Each *timestamp* - 7 bytes
- Each log taken - 3 bytes

In the two examples below, we have calculated the time it takes to fill up the memory for two different monitoring routines.

EXAMPLE 1

This example assumes a single-rate monitoring routine. When sampling at a non-variable rate, you can conserve memory by timestamping every *n*th log, i.e. the set-up parameter Logs per Timestamp can equal any number between 1 and 255. Let's assume you wish to take a log every 5 minutes and timestamp the data once every hour (= every 12th log). Setting the Logs per Timestamp parameter to 12, you calculate the time to fill the memory as follows:

Again, you start with 24,454 bytes after deducting 122 bytes for the set-up information. The data collection routine will use:

[(12 logs per hour x 3 bytes per log)+7 bytes per timestamp] = 43 bytes per hour.

To calculate the time necessary to fill up the memory, divide the total number of bytes available by the number of bytes used per hour:

24,454 bytes/43 bytes per hour = 569 hours or 23.7 days

It will take just under 24 days to fill the RAM of your AquiStar under this sampling routine.

This example demonstrates that you can conserve a substantial amount of memory by not timestamping every data log taken. Your retrieved data file will show times for all logs, since Terrasys 3.0 contains a feature that calculates times for all logs between the timestamps from the scan interval specified in the set-up of your sampling routine.

> **Note** The memory conservation feature mentioned above applies only to single-rate monitoring schemes. For variable-rate sampling routines, the set-up parameter Logs per Timestamp must equal 1.

EXAMPLE 2

You are setting up a variable-rate pump test. In a variable-rate sampling routine, the set-up parameter Logs per Timestamp must equal 1. Your data logger has 24 K of memory (24,576 bytes). The amount of memory available for the logging task is:

24,576 - 122 (for configuration) = 24,454

Therefore, the number of logs possible equals:

24,454/10 (7 for timestamp + 3 for each log) = 2,445 logs.

Your sampling scheme is as follows:

Scanning interval in sec	**Number of logs**
1	10
5	10
10	10
30	10
60	10
120	10
300	10
600	10
1200	10
2400	?

You know how many logs each you want to take for the first nine sampling intervals. The number of logs that can be taken at intervals of 2400 seconds will depend on the amount of memory left after the first nine sampling intervals.

Since each log consumes 10 bytes of memory, the first nine sampling intervals will use up:

9 intervals x 10 logs per interval x 10 bytes per log = 900 bytes.

To calculate the amount of time used for the first nine intervals, you multiply the number of seconds in each sampling interval by the number of logs taken at each interval and add the results. Time used, therefore, is:

(1x10)+(5x10)+(10x10)+(30x10)+(60x10)+(120x10)+(300x10)+(600x10)+(1200x10) = 23,260 seconds.

You know you have enough memory for a total of 2,445 logs. After deducting the amount of memory used for the first nine scanning intervals (1 through 1200 second logs), you are left with enough memory for 1,545 logs to be used for the last scanning interval, which is 2400 seconds (= 40 minutes). The time necessary to take 1,545 logs at 40-minute intervals is:

1,545 x 40 minutes = 61,800 minutes or just under 43 days.

Add to this the amount of time used for the first nine sampling intervals (23,260 seconds or 6.5 hours), and you find that, under this particular sampling scheme, you can collect data for slightly over 43 days before the memory of your AquiStar is filled.

IV FIELD CONSIDERATIONS

The AquiStar is designed such that it will withstand the normal wear and tear of prolonged field use. Certain precautionary measures are necessary nonetheless, in order to reduce the risk of damage to the equipment and insure maximized performance in the field. We strongly recommend you take the following precautions when installing the AquiStar in the field:

- Always test the unit with the sensor in the lab or office, and check to see if the configuration is correct for the particular monitoring task you plan to undertake.
- Recharge the main battery and check the voltage while the AquiStar is in wake mode (battery must be under a load to give a meaningful reading).
- Always install the AquiStar in an area well above any potential water level. While the AquiStar is splashproof, immersion will cause serious damage to the unit.
- Never position your data logger in such a manner that lightning may strike it. Any sensors attached to the unit should also be placed such that they will not attract a lightning strike.
- If there are any high-tension wires in the area, position your data logger and its attached sensor as far away from them as possible. In particular, do not place the sensor cable parallel to any cable carrying high voltage or high current. The currents travelling through the wires may adversely affect the accuracy and operation of the AquiStar.

After the unit is installed and ready to begin monitoring, you should check for proper operation before leaving the site:

- While in terminal mode, check the time clock of the AquiStar and make adjustments, if necessary. To display the time, select **1-Setup** from the main PGM3 menu and then choose the menu item **1-Time**.
- Check for proper operation of the sensor by selecting the **4-Monit** option of the main PGM3 menu. To get back to the main menu, press the <SPACEBAR>.
- If your scanning interval is short enough, you may wish to observe the screen for a short period of time to insure that the data logger wakes up at the specified time and that scanning is carried out as expected. For this purpose, select the **2-Acquisition** option from the main PGM3 menu and choose the appropriate item from the subsequent submenu.
- Inside the AquiStar, a small LED (light emitting diode) serves as wake/sleep indicator. You may wish to remove the lid of the data logger and observe this indicator for a short period of time to verify that the unit wakes up at the proper time and goes back into sleep mode after the scan (when the AquiStar goes into sleep mode, the indicator light goes out). Do not forget to replace the lid and secure it tightly before leaving the AquiStar unattended.

Having performed the precautions outlined in this chapter, you can safely leave your AquiStar in the field until you are ready to retrieve the collected data.

V WORKING WITH PGM3

The following chapter provides complete information about the operating software, PGM3, supplied with the AquiStar DL-1/DL-1A. Each menu is discussed in detail, including possible submenus, and examples are provided where appropriate.

ABOUT PGM3

PGM3 is a versatile operating program written for use in the single-channel AquiStar DL-1 and DL-1A. If you have used previously supplied programs (i.e. STD4, USR1) with Terra 8 data loggers, you will note quite an improvement. The cumbersome data statements, which required editing by the user in order to change the channel configuration and scan rates, have been eliminated and replaced by user-friendly menus and prompts that guide the user through all phases of his or her monitoring tasks, from configuration of the data logger to retrieval of the data after completion of the collection routine.

MENU CHART OF PGM3

Following is a diagram showing the menu structure of PGM3

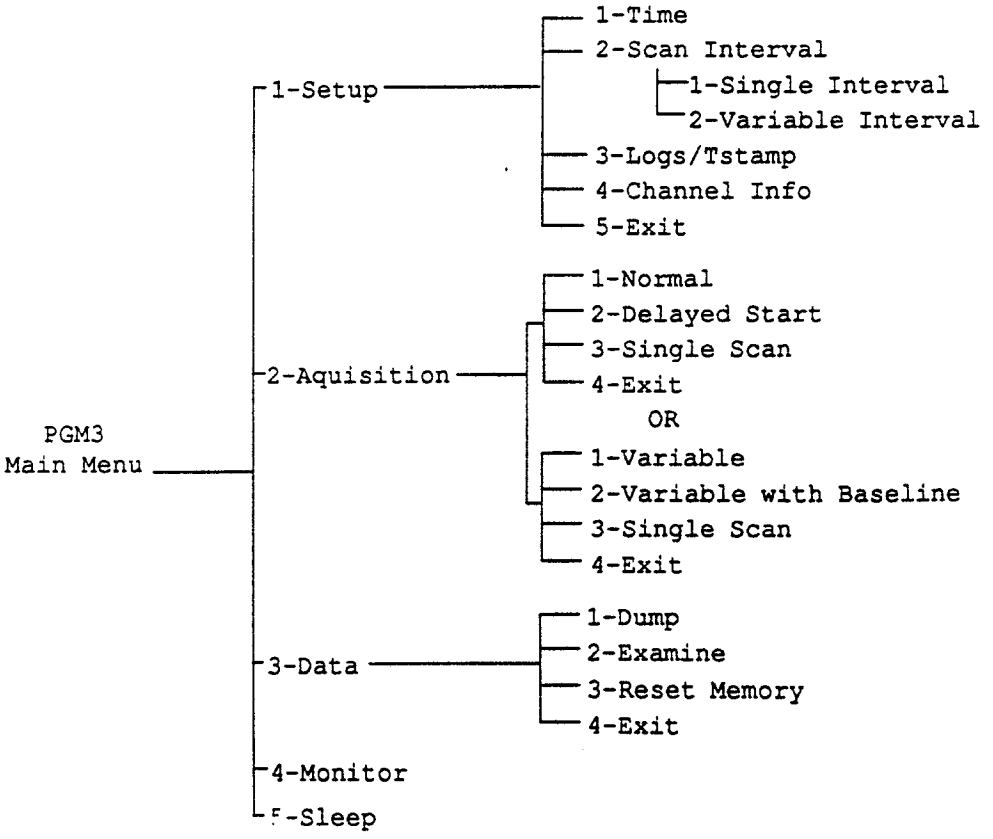

Figure 5.1 PGM3 Menu Chart

ACCESS TO THE PROGRAM

When you purchase a new AquiStar DL-1 or DL-1A, PGM3 is already preinstalled in the RAM of your data logger and ready for use. In the new AquiStar DL-1 and DL-1A models, a permanent copy of PGM3 resides in the EPROM chip of the data logger, from where it can be loaded into the workspace, if necessary. In older versions of the AquiStar (i.e. Mini 8 or Terra 8), the EPROM and workspace may contain previously supplied programs. If you own one of these units, you can still work with PGM3 by loading it into the RAM of your data logger from a diskette file. Chapter III, Getting Started, provides detailed instructions on how to access PGM3 when already in RAM, and how to load PGM3 from EPROM or diskette.

> **Note** In order to work with PGM3, you must first enable your computer to act as a terminal device by loading Terrasys 3.0 and selecting **Terminal Mode** from the **Terracom** menu.

USING THE MENUS

The following section of this chapter contains a detailed description of the PGM3 main menu and the submenus of each option. Examples are provided for clarification and convenience. All menu options are preceded by a number and a hyphen. To make a menu selection, simply type the appropriate number and press <ENTER>. If at any time, you wish to go back to a previous menu, simply select the appropriate **Exit** option, which is available in all menus except the main menu. To exit from the main menu and quit terminal mode, press the <ESC> key.

> **Note** In many menu-driven programs, selections are made by typing the first letter of the desired menu option. In PGM3, this will result in a "?Redo" message. Should you type a number inconsistent with those of the displayed menu options, you will exit the current menu and return to the previous one.

THE MAIN MENU

The main menu contains the following options:

Menu Option	Purpose
1-Setup	Lets you enter all the information necessary to set up your data logger for the particular data collection task you wish to carry out.
2-Acquisition	Starts the logging routine.
3-Data	Allows you to examine and/or retrieve the collected data and lets you reset the memory of the AquiStar for the next data collection task.
4-Monitor	Takes an immediate reading from the sensor and displays it to the terminal in engineering units. Does not store any data to memory.
5-Sleep	Puts the AquiStar into the low-power sleep mode.

THE SETUP MENU

Choosing the **1-Setup** option will result in a screen displaying the current configuration of the data logger, followed by a submenu of options for making changes to the existing settings. The submenu consists of the following options:

Menu Option	Purpose
1-Time	Lets you accept or change the current time and date.
2-Scan Interval	Lets you choose between single-interval or variable-interval sampling and set the time intervals at which you wish to sample.
3-Logs/Timestamp	Allows you to determine how often you want to timestamp your data. Note that for variable-interval sampling, this parameter must be set at 1.
4-Channel Info	Tells your data logger what type of sensor you are using, in which engineering units the data should be displayed, which conversion multiplier to use in order to convert the signals received from the sensor into the units displayed on the screen, which offset to work with, and the time period (in milliseconds) to allow for sensor warm-up.
5-Exit	Lets you exit the **Setup** menu and return to the main menu.

In order to configure your AquiStar for the data collection routine you wish to perform, you work through the applicable menu options. The following paragraphs describe each menu item and related entries in detail.

1-Time

Select **1-Time** to display the current time and date on your screen. To accept them as shown, simply type Y for "Yes" and press <ENTER>. Then proceed to the next menu option. If you wish to change the date and time, type N for "No" and press <ENTER>. You will be prompted to enter the correct month and day in the format "MM/DD". The two values must be separated by a slash, otherwise the program will abort. After typing the correct month and day, press <ENTER>. The screen will now prompt you for the correct time, which must be entered in the format "HH/MM/SS", using two digits for each value and slashes for separation. You must use the 24-hour format for entering time. Press <ENTER> after typing the correct time.

Example: January 5 would be entered as "01/05", and 30 seconds after 5:05 p.m. would be entered as "17/05/30".

2-Scan Interval

When you select this menu option, another submenu will be displayed:

1-Single Int. 2-Variable Int. 3-Exit

This submenu gives you a choice between single-interval and variable-interval sampling. If you want to keep sampling at the same interval throughout the entire data collection period, select **1-Single Int.**. The screen will display the default single-interval setting and prompt you to accept or change it. To accept, simply type **Y** and press <ENTER>. To change the scanning interval, type **N**, followed by <ENTER>. Type the desired sampling interval in the format "HH/MM/SS" (2 digits for each item, separated by a slash). Any value between 00/00/00 and 23/59/59 is allowed. You must enter zeros in those positions where no value is desired (e.g. to set an interval of 15 minutes, you would enter "00/15/00"). Press <ENTER> after typing in the sampling interval.

> **Note** If you enter "00/00/00", the AquiStar will collect data at maximum speed. With a short warm-up time, the AquiStar can actually log at a maximum speed of .3 to .4 seconds between readings. If the scanning interval is less than 3 seconds, the AquiStar will not go into sleep mode during the collection period.

Example: You want to set up your AquiStar to log in intervals of 5 minutes throughout the entire data collection period. From the **Setup** menu, select **2-Scan Interval**. In the subsequently displayed submenu, select **1-Single Int.** and then type **N** in order to change the default interval. When prompted to enter the scan interval, type "00/05/00" and press <ENTER>. The program will return to the **Setup** menu, and you can proceed to the next menu option.

If you want to set up your sampling routine at variable intervals, you choose the option **2-Variable Int.** after having selected **2-Scan Interval** from the **Setup** menu. The screen will display a default value for the *baseline interval*, which represents a constant sampling interval that is used until collection at variable intervals starts.

> **Note** The baseline interval must be at least one second. If you don't wish to use a baseline interval, accept the default value displayed on the screen. The **Acquisition** menu will provide an option to start variable-interval scanning without a baseline interval. If you wish to set up variable intervals with a delayed start, enter a large value for the baseline interval and select **2-Variable with Baseline** in the **Acquisition** menu.

To accept the default baseline interval, type **Y** and press <ENTER>. If you wish to change the baseline interval, type **N**, follwed by <ENTER>; when promted for a new interval, type desired interval in hours, minutes, and seconds (HH/MM/SS) and press <ENTER>. The program will ask you to confirm the new baseline interval. The screen will next display the default set of variable intervals and the numbers of scans at each interval, and will prompt you to accept or change this setting. To accept, type **Y**, followed by <ENTER>. If you wish to change the variable intervals, type **N** and press <ENTER>. The screen will prompt you for the number of scanning intervals you want to use. Type the desired number (permissible numbers range from 1 to 20) and press <ENTER>. You will then be asked to indicate the first scanning interval in seconds. Type the desired number of seconds (number must be greater than 1) and press <ENTER>. When prompted for the number of logs to be taken at this interval, type the desired number (number must be greater than 1) and press <ENTER> again. Repeat this process for each scanning interval. After you have entered all scanning intervals, the program will return to the **Setup** menu.

Example: Your test requires three variable rates. You want to take 24 logs at 5-second intervals, 20 logs at 15-second intervals, and 120 logs at 60-second intervals. And you wish to set up a baseline interval of 2 seconds. From the **Setup** menu, select **2-Scan Interval**. In the subsequently displayed submenu, choose the option **2-Variable Int.**. When prompted to

accept or change the default baseline interval, type N, followed by <ENTER>. Type "00/00/02" at the subsequent prompt, followed by <ENTER>. Confirm the new baseline interval at the next prompt. When asked for the number of scanning intervals, type "3" and press <ENTER>. For the first scanning interval in seconds, type "5", followed by <ENTER>. When prompted for the number of logs at this interval, type "24" and press <ENTER>. Repeat the last two steps for the remaining two scanning intervals. The program now returns to the **Setup** menu and you can go on to the next menu option.

> **Note** When setting up any logging schedule, you need to insure that you will have sufficient memory to carry out the routine. For details on how to calculate the time it takes to fill the memory, please refer to Chapter III, Getting Started.

3-Logs/Tstamp

This parameter tells your AquiStar how often you wish to insert a timestamp into the collected data. For variable-rate sampling routines, a timestamp must be included with each data log. Therefore, the parameter logs/timestamp must be set at 1. For single-rate sampling schemes, any number between 1 and 255 is permissible. When selecting **1-Setup** from the main menu, the parameter logs/timestamp is displayed on the screen together with all other default settings. If the default value is appropriate for the sampling routine you wish to perform, no further action is necessary for this set-up item. If you wish to change this parameter, select **3-Logs/Tstamp** from the **Setup** menu. The screen will show the default value and prompt you to accept or change it. Type the desired number and press <ENTER> (e.g., entering "24" would mean that every 24th data log would include the time at which it was taken). The program will return to the **Setup** menu.

> **Note** Inserting timestamps with the data consumes large amounts of memory. When performing single-interval sampling routines, you can conserve memory by timestamping only every nth log. When the data is uploaded to disk, Terrasys 3.0 calculates the time for each unstamped data log from the scan interval specified in the set-up. Remember, however, that this conservation feature does not apply to variable-rate monitoring tasks.

4-Channel Info

When you select this option from the **Setup** menu, your screen will display the default values for the sensor description, display units, conversion multiplier, offset, and warm-up time. In order to accept all default values, simply press the <ENTER> key. If you wish to change the existing values, type in the desired changes and press <ENTER> after each entry. The program will prompt you, step-by-step, to fill in the new information for each item.

Sensor Description

This parameter will accept a value comprised of any mix of numbers and characters, up to a total of 18. For example, if you are using a 15 psi pressure transducer, you may wish to enter "15 psi" as the sensor description. You may also find it useful to include the serial number of the transducer or the site name/well number in this description to later differentiate between various tests in one data file.

Display Units

The term *display units* refers to the engineering units used to identify the collected data. For example, when working with a pressure transducer, you can use the conversion multiplier and offset to display the collected data as any appropriate unit of pressure (psi, mm water, kPa, ft water, inches H_20). The value for this parameter can be any mix of numbers and characters, up to a total of 8.

Conversion Multiplier

The *conversion multiplier* is the number used to convert the sensor output, which appears at the analog-to-digital converter, into engineering units. Any number from 1E+32 (10 to the power 32) to 1E-32 can be entered. To calculate the conversion multiplier for your sensor, you divide its full-scale sensor range by 4. Depending on the display units you have chosen, you may still have to apply a conversion factor to the result.

Example: If your display units are to be "psi" and you wish to calculate the conversion multiplier for a 100 psi sensor, the following equation applies:

100 psi/4 = 25 psi

If the display units are to be "feet" instead, you use the equation below:

100 psi/4 x (2.31 ft/psi) = 57.75

For the user's convenience, the following table provides conversion multipliers and corresponding offsets for common pressure transducer ranges.

Conversion Multipliers and Offsets for Common Pressure Transducer Ranges (display units in feet)

Range (psi)	Conversion Multiplier (m)	Offset (b)
5	2.8875	-2.8875
10	5.7750	-5.7750
15	8.6625	-8.6625
20	11.550	-11.550
30	17.325	-17.325
50	28.875	-28.875
100	57.750	-57.750

Note The AquiStar converts a 0-20 milliamp sensor signal into a 0-5 volt reading at its analog-to-digital converter. If you have been using a TERRA 8 or 8D unit, this is different from the 4-20 milliamp sensor range covered by these units. The use of a 0-20 milliamp range allows detection of loss of signal from a dead sensor or damaged cable, however it slightly decreases the resolution of the signal due to the larger range. A bad sensor loop will be indicated by a negative sensor reading!

Offset

The *offset* is the number (range 1E+32 to 1E-32 is possible) added to the product of the sensor output and the conversion multiplier in order to obtain engineering units, as illustrated in the following equation:

$$y = mx + b$$

where

- *y* is the displayed reading in engineering units
- *m* is the conversion multiplier
- *x* is the voltage signal at the analog-to-digital converter
- *b* is the offset

To calculate the offset for your sensor, you multiply the conversion multiplier from above by -1. For the sensor in the above example, the offset would be -25 (if display units are to be psi) or -57.75 (if display units are to be feet).

When the AquiStar is configured thus, the pressure transducer in our example hanging in free air will display 0.00 ft; under 60 feet of water, the log and screen display will record 60 ft.

For information about alternative water level referencing, please refer to Appendix B.

Warm-Up Time

The *warm-up time* is the delay between applying excitation (power) to the sensor and taking the reading from the sensor. This delay insures that a stable reading will be obtained and is necessary each time a reading is taken, due to the fact that the AquiStar goes into the low-power sleep mode after each log. The value for the warm-up time must be entered in milliseconds and can range from 0 to 32,000. Experience has shown that a delay of 100 milliseconds works well with pressure transducers. Sensors that are slower to stabilize (e.g. conductivity sensors) will require longer warm-up times.

> **Note** The warm-up time must never be longer than your shortest scanning interval. Otherwise, incorrect scanning times or errors will result.

If you are not sure what delay to use, you can conduct a simple test. Set up a long warm-up time (e.g. 5000 milliseconds), then select the **4-Monitor** option from the main menu and check the reading you obtain on the screen. Gradually decrease the warm-up time, checking the reading for each different delay via the **4-Monitor** option, until a different reading is obtained. Take the warm-up time you have set up at this point and double it for a safe value with which to work.

> **Note** A long warm-up time consumes more power and reduces the life of the battery.

After you have entered all the set-up parameters required under the menu option **4-Channel Info**, the program will return to the **Setup** menu.

5-Exit

By selecting this option, you will leave the **Setup** menu and return to the main PGM3 menu.

THE ACQUISITION MENU

The **Acquisition** menu is the starting point for executing the logging routine you have set up. It consists of two separate menus, one for single-rate and the other for variable-rate scanning. When you select **2-Acquisition** from the main menu, the program will automatically display the correct **Acquisition** menu for the logging routine you have previously set up. After you have started the data collection task by choosing one of the menu options described in the following two sections, you may leave your data logger unattended in the field by simply disconnecting the serial cable.

Single-Rate Scanning

The **Acquisition** menu for single-rate scanning contains the following options:

Menu Option	Purpose
1-Normal	Starts logging immediately at the preset interval.
2-Delayed Start	Starts logging at the preset interval at a given date and time.
3-Single Scan	Takes one log, which is displayed to the screen and stored in memory, and returns to the **Acquisition** menu.
4-Exit	Leaves the **Acquisition** menu and returns to the main PGM3 menu.

The following paragraphs provide a detailed description of each menu item.

1-Normal

When you select this option from the **Acquisition** menu, the program will immediately start the logging routine at the preset interval and store the collected data in memory. Before the first log, the screen will display the date and time at which the memory will be filled up. Information about each log is then displayed as the sampling routine continues.. This information consists of the following:

Log Number
Remaining Memory (e.g. "RMEM=24314")
Real Time
Analog Channel Number and
  Reading in Engineering Units (e.g. "A Chan (1)=25 ft")
Next Calculated Wake Time

Wake time is displayed to let you know that the data logger has gone into the low-power sleep mode and will wake up at the calculated time to take the next data reading. If you wish to communicate with the AquiStar at this point, you must manually wake it by holding down the <SHIFT>+<C> keys, until the main menu appears on the screen.

Note Logs taken at intervals smaller than 3 seconds will not be shown on the screen. The program will display some graphic characters instead. To regain communications with the data logger in this situation, simply press the <SPACEBAR> to return to the main menu.

2-Delayed Start

This menu option allows you to set a future starting date and time for your logging routine. When selecting **2-Delayed Start** from the **Acquisition** menu, you will be prompted to enter a start date and time. The program first expects the month and day in the format "MM/DD", then the time in the format "HH/MM/SS". Remember to use zeros in the unused positions. The program will display the start time for the logging task, if it is less than 30 days away, otherwise the following warning will appear on the screen:

"* Warning - Start delay > 30 days"

If you see this message, you may wish to double check your entry to insure that the date and time entered are actually in the future. If you had erroneously entered a date or time that was in the past, the AquiStar would presume this date or time to be in the following year. Therefore, if you ignored the warning, data collection would not start for a very long time!

The program will next display the time at which the memory will be full, as well as the next calculated wake time. To communicate with the data logger in this situation, you must manually wake the unit.

3-Single Scan

Sometimes you may wish to take just one immediate reading from the sensor, regardless of how the scanning schedule is set up. You can do so by selecting **3-Single Scan** from the **Acquisition** menu. The screen will display the log number, remaining memory, time, and the analog channel with the actual reading. At the same time, the data is stored in memory. After taking the reading, the program returns to the **Acquisition menu**. Each log taken via the **3-Single Scan** option will include a timestamp, irrespective of how many logs/timestamp were declared in the set-up.

4-Exit

This option allows you to leave the **Acquisition** menu and return to the main PGM3 menu.

Variable-Rate Scanning

The **Acquisition** menu for variable-rate sampling contains the following options:

Menu Option	Purpose
1-Variable	Starts logging immediately at the preset variable-rate intervals.
2-Variable with Baseline	Starts logging immediately at baseline rate; variable-rate scanning does not begin until a predefined start time is reached.

3-Single Scan	Takes one log, which is displayed to the screen and stored in memory, and returns to the **Acquisition** menu.
4-Exit	Leaves the **Acquisition** menu and returns to the main PGM3 menu.

Each menu option is discussed in the following paragraphs.

1-Variable

Select this menu option if you wish to start logging immediately at the variable rates you predefined in the set-up. The data is stored into memory and displayed on the screen in the same fashion as in single-rate scanning described above. While logging at intervals of less than 3 seconds, it is not possible to regain communication with the data logger in this scanning mode. As soon as scanning intervals are greater than 3 seconds, communication with the AquiStar can be achieved by manually waking the unit.

> **Note** Remember also that only logs taken at greater than 3-second intervals are displayed to the screen.

If you have just completed the set-up of your AquiStar and select **1-Variable** from the **Acquisition** menu, data collection will begin as soon as you press the <ENTER> key. No further prompts will appear on the screen. However, if some logs have already been taken (e.g. the test was started and interrupted) when you select **1-Variable**, the program will display the following message:

> "Resume series? (Y/N)?"

If you wish to continue the same test at the point where it was interrupted, type **Y** and press <ENTER>. Logging will start at the exact point where it was interrupted. If you would rather start a new test, beginning with the first predefined variable-rate interval (e.g. recovery after draw-down), type **N** and press <ENTER>. In either case, logging will commence immediately after you press the <ENTER> key.

2-Variable with Baseline

This menu option has a similar function as **2-Delayed Start** in single-rate scanning routines. The difference lies in the fact that here, the program will immediately start logging at a preset, linear interval until the specified start time, when it will switch to variable intervals. When selecting **2-Variable with Baseline**, the program prompts you for a start date and time. Enter the month and day in the format "MM/DD", then the time in the format "HH/MM/SS". If the start date and time for the variable-rate scanning are less than 30 days away, the program will now display the length of time before variable-rate scanning will begin. In case the start date and time are more than 30 days away, your screen will show a warning message.

> **Note** Remember that it is important to double check your start time, if you receive a warning message. Otherwise, the AquiStar might erroneously scan at the baseline rate until the memory is full or the battery used up.

If you wish to interrupt the data collection, you can do so by manually waking the data logger and returning to the main menu.

When the program is interrupted in this manner, a test can be resumed at the exact point where it was stopped, if it had already progressed into the variable-rate portion of the routine. To do so, select **2-Acquisition** from the main menu and choose the option **1-Variable**. The screen will prompt you to resume the series and you can confirm by typing Y and pressing <ENTER>. If the test was interrupted while still scanning at baseline rate, the program will ask you to enter a new start time, when you select **2-Variable with Baseline.**

3-Single Scan

When you select this menu option, the program will take one reading from the sensor. The log number, remaining memory, time, and the analog channel with the actual reading will be displayed to the screen, and the data will be stored into memory. The program then returns to the **Acquisition** menu. Each log taken in this manner will be timestamped, regardless of how many logs/timestamp you predefined in the set-up.

4-Exit

This menu option allows you to leave the **Acquisition** menu and return to the main PGM3 menu.

As a final note regarding the **Acquisition** menu, please remember the following: When interrupting any acquisition task for any reason, you must specifically start the process again by selecting your particular acquisition routine from the **Acquisition** menu.

Once a preset acquisition task is completed or the memory of the data logger is full, whichever comes first, the AquiStar will automatically go into the low-power sleep mode. No data will be overwritten.

THE DATA MENU

The Data menu enables you to retrieve the collected data. You can review the data on your screen, as well as transfer the records to your computer's hard disk or onto a floppy diskette. Another function of the **Data** menu is to reset the memory of the AquiStar, i.e. delete all collected data.

If the data logger has been in the field for a long period of time, it is recommended that you replace the main battery with a fully charged one before retrieving the data. The most convenient method for transferring the data is to take a laptop computer, a blank diskette for the data file, and a copy of the Terrasys 3.0 diskette with you into the field. However, in very cold temperatures, the screens of many laptops may cease to function, and you may have to take the data logger back to your office or lab to perform the data transfer.

The Data menu contains the following options:

Menu Option	Purpose
1-Dump	Allows you to transfer the data from the memory of the AquiStar to your terminal (either to hard disk or floppy diskette).
2-Examine	Lets you review the collected data on your screen before transferring it.

3-Reset Memory	Lets you delete the data from the memory of the AquiStar.
4-Exit	Leaves the **Data** menu and returns to the main PGM3 menu.

Each of the menu options will be discussed in detail in the following paragraphs.

1-Dump

In order to transfer or *dump* your data, you will be required to work with both PGM3 and Terrasys 3.0. When dumping data, you actually copy it from the memory of the data logger onto a diskette or hard disk in your computer. The data still remains in the AquiStar's memory, until the memory is reset. This way, if anything should happen during the copying process that might corrupt the data transfer (e.g. a faulty diskette or disconnected cable, etc.), you still have the original data in memory and can repeat the dumping process.

Depending on the size of your test, you may not wish to dump the collected data after every test. In this case, we recommend that you keep notes about the specifics of each test (e.g. type of sensor used, start and end times of test). This will facilitate data identification later, since all collected data is transferred into one diskette file during the dumping process. Another way to differentiate between tests is to change the "sensor description" block (e.g. change "5psi/MW2" to "5psi/MW3").

To carry out a data dump, you select **3-Data** from the main PGM3 menu and then choose the option **1-Dump**. Your screen will display the following message:

> "Press <Esc> to set upload. Press <Enter> when upload mode message appears in the upper right corner of screen?"

Before continuing the data dump, you must first designate a file, to which the data can be sent, and insure that your computer is in upload mode and ready to receive the data.

> **Warning** If you press the <ENTER> key before your computer is in upload mode and a filename has been designated, no data will be stored in your computer!

To designate a filename, exit terminal mode by pressing the <ESC> key. Your screen will now show the **Terracom** menu. Select the menu option **Upload to Disk** and press <ENTER>. The top of your screen will display the following message:

> "Upload to File —>"

followed by the default drive of your computer (if your computer has a hard disk, the display may also show the default directory). Type in the name of your designated data file, including the correct disk drive and directory, if applicable (a legal filename consists of up to 8 characters, followed by a period and a file extension of up to 3 characters), and press the <ENTER> key. (For example, to transfer the data to a file named "h20test.hex" in the "data" directory of your computer's hard drive, type "c:\data\h20test.hex" at the prompt).

Again, you will see the message "Press <Esc> to set upload. Press <Enter> when upload mode message appears in the upper right corner of screen?" In addition, the upper right hand corner of your screen will indicate that you are now in upload mode. Now you press <ENTER> in order

to execute the data dump. The collected data, in hexadecimal format, will be displayed on your screen as it is being transferred to the designated file.

When all data has been transferred, your screen will display the message:

"Press <Esc> to terminate upload and close file".

It is important to follow this instruction, because pressing the <ESC> key will terminate upload mode and close the uploaded file. The program will return to the **Terracom** menu, from where you can either view the uploaded file in the Terrasys 3.0 utility or switch back to terminal mode to regain communication with your data logger.

> **Note** It is recommended that you always view your uploaded data file in Terrasys 3.0 before you reset the memory of your AquiStar. This way, you can insure that data transfer has been completed successfully.

For details about the Terrasys 3.0 utility, please read Chapter VI, Working with Terrasys 3.0.

2-Examine

This menu option gives you the opportunity to view all or a portion of the collected data before transferring it to a hard disk or diskette file in your computer. When selecting **2-Examine** from the Data menu, the screen will prompt you for a starting log number:

"Start at Log# (1)?"

If you want to start the review with the very first log, simply press <ENTER>. To start reviewing at a specific log number, type the desired number and press <ENTER>. The program will then ask for an ending log number:

"End at Log# (End)?"

Pressing <ENTER> indicates to the program that you want the review to end with the last log. If you want the review to stop at a particular record, type in the desired log number and press <ENTER>.

The portion of the records you selected will scroll across your screen. To stop the review action before it is completed, simply press the <SPACEBAR>. The program will then return to the Data menu.

3-Reset Memory

This menu option removes all recorded data from the memory of the AquiStar and should be used with caution. Once the reset function is performed, data can no longer be retrieved from the data logger. Therefore, you want to be sure that your data has been uploaded to your computer, before you reset the memory. PGM3 contains a number of safeguards that will prevent you from accidentally deleting your data.

If you wish to reset the memory of your data logger, select **3-Reset Memory** from the **Data** menu. If data has not been dumped since the last log to memory, the screen will display the following warning:

"Data Not Recovered - Proceed (Y/N)?"

To abort the reset process, type **N** and press <ENTER>. The program will return to the **Data** menu. If you ignore the warning and type **Y**, followed by <ENTER>, another warning will appear on your screen:

"Reset Data Memory (Y)?"

This is your last chance! To abort the action, type **N** and press <ENTER>; the program will return to the **Data** menu. If you type **Y**, followed by <ENTER>, the memory will be reset. The screen will display the message "Reset Done" and show the current configuration of the data logger. The program will return to the main PGM3 menu.

THE MONITOR OPTION

The **4-Monitor** menu option of the main PGM3 menu allows the user to test the sensor operation and calibration prior to carrying out a data collection routine. When you select **4-Monitor**, the sensor is scanned, and the readings are sent to the screen but not stored in the memory of the AquiStar.

To test the sensor, select **4-Monitor** from the main menu. The message "Monitoring - Spacebar to Exit" will appear on the screen, followed by sensor readings. You can stop the monitor function at any time by pressing the <SPACEBAR>. Unless stopped earlier, the program will take 500 readings and then return to the main menu.

THE SLEEP OPTION

The **5-Sleep** option of the main PGM3 menu can be used to manually put the AquiStar into the low-power sleep mode, e.g. when storing the unit. In most situations, this function is not necessary, since the automatic timeout feature of the AquiStar will be activated after 3 minutes of inactivity.

> **Warning** Putting your data logger into sleep mode via this menu option will override any acquisition routine you may have previously started!

VI WORKING WITH TERRASYS 3.0

The following chapter introduces you to the communications/utilities software supplied with your AquiStar DL-1 or DL-1A. The first portion of this chapter provides general information, such as how to back up your program diskette, how to install Terrasys onto a hard drive, and how to access the program. It also gives a brief overview of the basic Terrasys functions available at the main menu level and describes the use of the directory and quit functions, which are available at each level of the program. The second portion of this chapter contains a detailed description of the Terrasys functions as they relate to the **Terracom** menu, which constitutes the communications package of Terrasys, and the **Terravue** menu, which represents the data interpreter. Sample screens have been included for the user's convenience to illustrate the various functions and explain available options.

ABOUT TERRASYS 3.0

Terrasys 3.0 is a menu-driven software program which consists of a terminal emulation package (**Terracom**) and a data interpreter program (**Terravue**). The terminal emulator allows users to communicate with their data logger, thereby enabling them to program and control data logger functions. With the data interpreter program, users can view and manipulate uploaded data, as well as convert data into printer or spreadsheet compatible files.

Users of earlier versions of Terrasys will note that a number of enhancements have been added to make the program easier to use. Certain functions have been eliminated, such as those relating to the use of data cassette recorders, since these devices are not commonly used any longer. Data files created with an earlier version of the program are compatible with Terrasys 3.0.

BACKING UP THE PROGRAM DISKETTE

In order to protect your program, you should make a back-up copy of the diskette supplied with this package and keep the original in a safe place. Use the back-up diskette as a working copy for day-to-day operations.

> **Warning** Do not remove the write-protect tabs from your Terrasys diskette!

Terrasys is not copy-protected. To make a working copy of your program diskette, follow the instructions appropriate to your system configuration.

FOR USERS WITH TWO FLOPPY DRIVES

If your computer system has two disk drives, follow these steps to make a copy of your program disk. You will need your original Terrasys diskette, your DOS diskette, and one blank diskette.

1. Insert your DOS diskette in Drive A.

2. Insert the blank diskette in Drive B.

3. With the A:> prompt on the screen, type

   Format B:/S

   and press <ENTER>. You will be prompted to press any key.

4. When formatting is complete, the system will ask if you wish to format another. Type N for "No"

5. Remove your DOS diskette from Drive A and insert your Terrasys diskette into Drive A. Leave the now formatted blank diskette in Drive B.

6. Copy all files on the Terrasys diskette in Drive A to the blank diskette in Drive B by typing

   Copy A:*.* B: followed by <ENTER>

7. When all files have been copied (screen will display the number of files copied), remove the Terrasys diskette from Drive A and store it in a safe place. The working copy you have created in Drive B will have the DOS system files on it, if you have followed this procedure. Therefore, it will be a *bootable* disk.

FOR USERS WITH A SINGLE DISKETTE SYSTEM

If your computer system has only one floppy drive (and no hard disk), take the following steps to make a working copy of your Terrasys diskette. You will need your DOS diskette, your Terrasys diskette, and one blank diskette.

1. Insure that your DOS diskette and the Terrasys diskette are write-protected by covering the notch on the side of the diskette with an adhesive tab.

2. Insert your DOS diskette into the drive and type

   Format A:/S

   and press <ENTER>. The option /S you added to the formatting command will insure that your blank diskette will be formatted as a system diskette (i.e. it will contain the DOS system files and, therefore, be a bootable disk).

3. When prompted to insert a new diskette, remove the DOS diskette and insert the blank diskette into the drive.

4. When formatting is complete, the system will ask if you wish to format another. Type N and press <ENTER>.

5. Remove the newly formatted diskette and insert your Terrasys diskette into the drive. Type:

   Copy A:*.* B:

   and press <ENTER>.

6. The system will read the Terrasys files into memory and write them to the formatted diskette. You will be prompted, alternately, to insert the source (Terrasys) or the target (formatted) diskette into the drive.

7. When the DOS prompt (A:>) returns to the screen, the copy process is completed. The diskette to which you copied the Terrasys files is now ready to be used as a working copy. Store the original Terrasys diskette in a safe place.

INSTALLING TERRASYS ONTO A HARD DRIVE

If your computer system has a hard (fixed) drive and one or two floppy drives, you can transfer the Terrasys files to a directory on your hard drive. To do so, follow these steps:

1. Create a sub-directory for the Terrasys files. At the C:> prompt, type

   MD \Terrasys followed by <ENTER>.

2. Change directories to the newly created Terrasys sub-directory by typing

   CD \Terrasys followed by <ENTER>.

3. Insert the Terrasys diskette into floppy Drive A.

4. Copy all of the Terrasys files to the hard drive by typing

   Copy A:*.* followed by <ENTER>

   or

   XCopy A:*.* followed by <ENTER>

5. Your screen will show the file names as they are transferred to the Terrasys sub-directory.

ACCESS TO THE PROGRAM

To start Terrasys 3.0 when you first boot up your computer, simply type **Terra3** at the DOS prompt and press <ENTER>. Be sure to verify that your default drive is the one containing the Terrasys program. If this is not the case, change to the drive that contains the Terrasys diskette (or change to the directory that contains the Terrasys program, if you have installed Terrasys onto a hard drive), and then type **Terra3** and press <ENTER>.

Terrasys 3.0 is completely menu-driven, which means that all tasks can be performed by selecting the appropriate option from a menu of choices available at each level of the program. When you start the program, the main Terrasys menu will be displayed. Selections can be made by either using the arrow keys to highlight the desired item and pressing <ENTER> or typing the first (highlighted) letter of the desired menu item and pressing <ENTER>. When you select a menu item, the program may display another menu or screen at the next level to help

you select the functions you require. The overall program structure is shown in Figure 6.1 in the next section of this chapter.

At any point in the program, the <ESC> key may be used to terminate an operation and return to the previous menu. If you are working in terminal mode, pressing the <ESC> key will terminate this mode and return the **Terracom** menu to the screen.

TERRASYS FUNCTIONS

The Terrasys program has four basic functions: communication with the data logger, viewing and printing of collected data, viewing of file directories, and the escape function which allows the user to terminate a current operation or exit the program. The flowchart in Figure 6.1 gives you an overview of the Terrasys program.

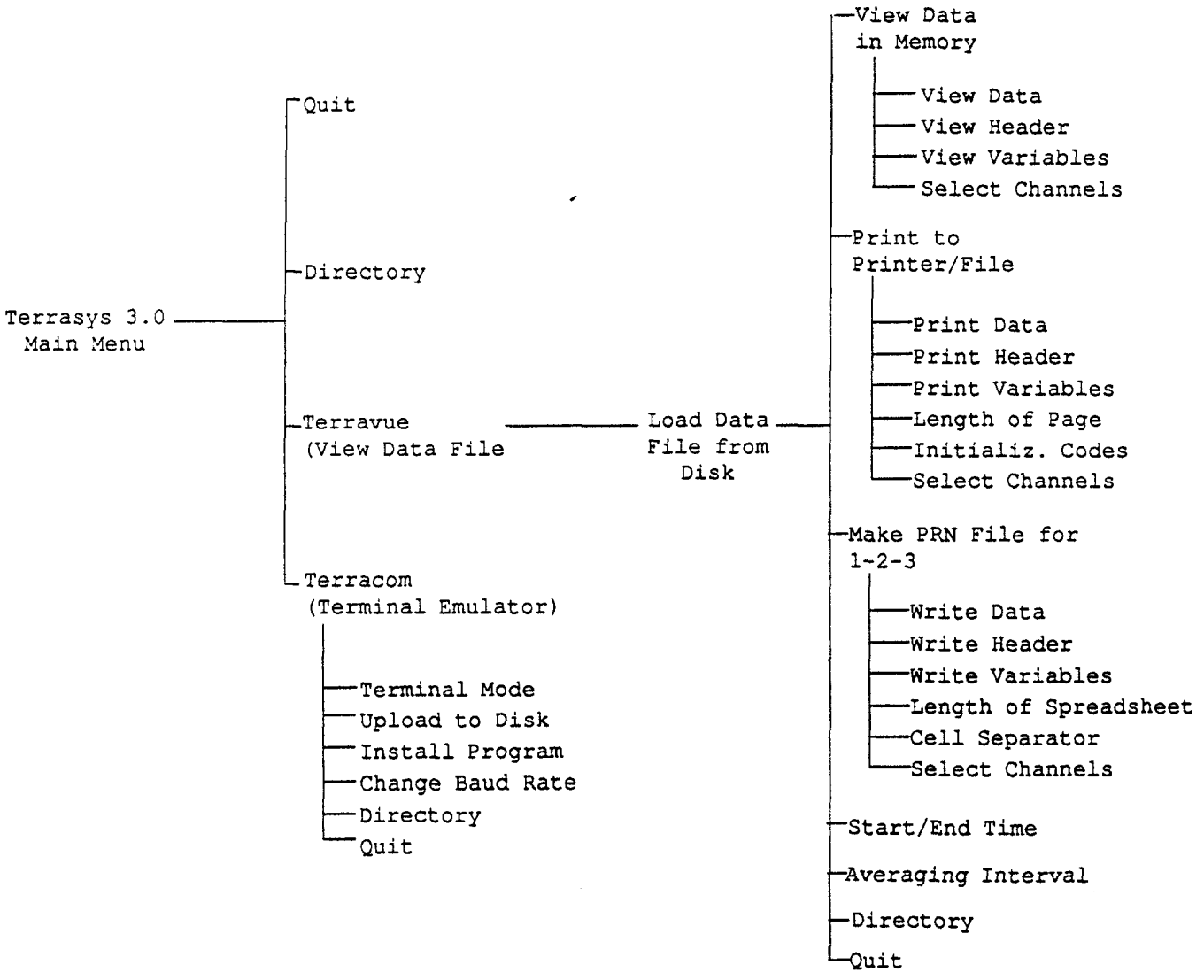

Figure 6.1 Structure of the Terrasys Program

THE MAIN TERRASYS MENU

When you first access the Terrasys program, the main menu as shown in Figure 6.2 will be displayed on your screen.

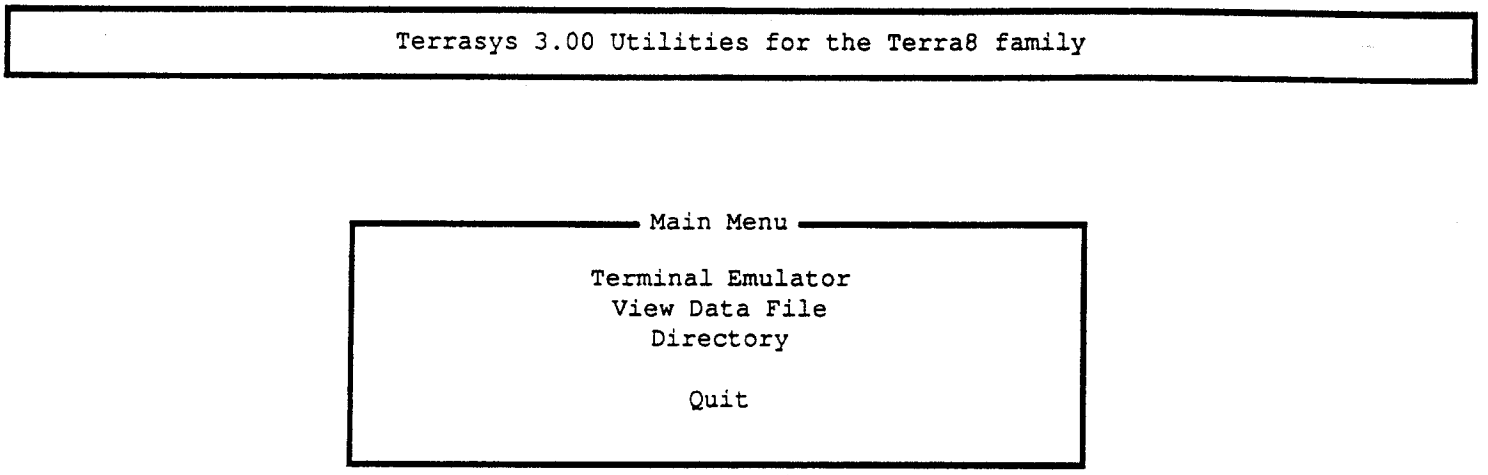

Figure 6.2 Main Menu Display

The following table provides a general overview of the functions listed in this menu.

Menu Option	Purpose
Terminal Emulator	Displays the **Terracom** menu. Allows you to communicate with your data logger by designating your computer as the terminal through which you control data logger functions.
View Data File	Displays the **Terravue** menu. Lets you access the data interpreter package of the Terrasys program and allows you to view, manipulate and print the collected data.
Directory	Lets you view the directory of a specified drive or change to a desired new directory without exiting Terrasys.
Quit	Allows you to back up one step at each level of the program. At the main menu level, this selection exits the program.

Since the menu options **Directory** and **Quit** are available at most levels of the program, they are described in detail below. This avoids repeating the explanation at each appropriate step. Detailed discussions of the **Terracom** and **Terravue** portions of the Terrasys program follow in separate sections of this chapter.

The Directory Function

Many of the Terrasys utility functions require that the user supply a filename and path. The Directory function provides an easy way for the user to view the files of a specified drive and/or directory. When you select the **Directory** option, a submenu as shown in Figure 6.3 appears

on the screen, presenting two further options: **Directory Listing** to produce a listing of all files in the current directory, and **Change Directory** to allow you to change to a different directory.

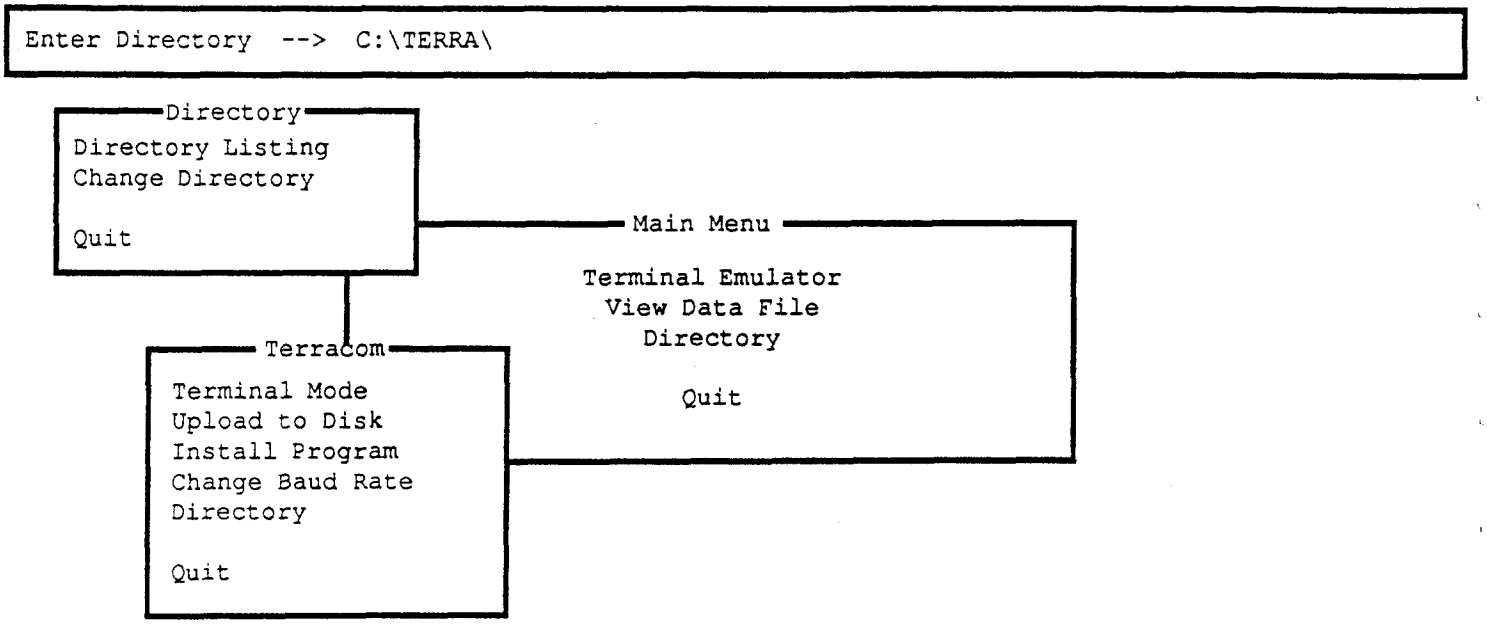

Figure 6.3 Directory Function Display

If you select **Directory Listing**, the window at the upper edge of the screen will prompt you to either accept the current drive path by pressing <ENTER> or to edit the display by specifying a different drive path. Pressing <ENTER> has the same effect as the MS DOS command **Dir**, and the contents of the specified directory will appear on the screen. To return to the previous Terrasys menu, simply press any key.

If you select the menu option **Change Directory**, the top window on your screen will display the default drive path and ask you to specify a new directory. This selection is equivalent to the MS DOS command **CD** and will cause the default drive path to be changed, as soon as you type the new path and press <ENTER>. The contents of the specified directory will also appear on the screen. To return to the previous Terrasys menu, press any key.

The Quit Function

The **Quit** function is available in all menus and submenus of the Terrasys 3.0 program. It terminates whatever operation you have started and returns to the previous menu level. Therefore, if you have made an incorrect menu selection and advanced to a new submenu, you can return to the previous menu and correct your mistake by selecting **Quit**. You may also use the <ESC> key to interrupt your current task and return to the previous menu. The function of the <ESC> key is identical to that of the **Quit** option; it is useful in those areas of the program where no menu is available.

THE TERRACOM MENU (TERMINAL EMULATOR)

The **Terracom** menu, as shown in Figure 6.4, provides all the necessary functions for interaction with the AquiStar.

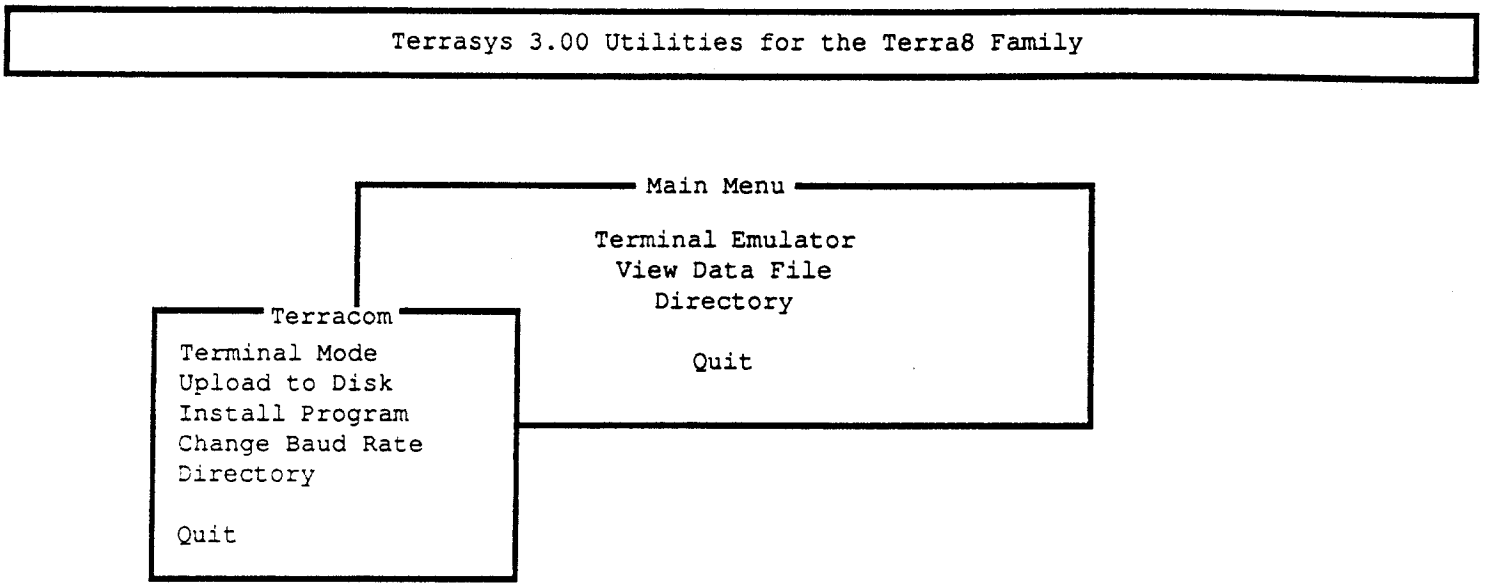

Figure 6.4 Terracom Menu Screen

To display the **Terracom** menu on your screen, select **Terminal Emulator** from the main Terrasys menu. The **Terracom** menu contains the following options:

Menu Option	Purpose
Terminal Mode	Allows you to communicate with your data logger in order to program and control its functions.
Upload to Disk	Uploads collected data or a TERRABASIC program listing from the data logger to a specified disk file on your computer.
Install Program	Lets you *download* (transfer) new TERRABASIC program files from a specified disk file of the computer to the memory of the AquiStar.
Change Baud Rate	Allows you to change baud rate and other communications parameters for two serial ports on the computer, COM1 and COM2.
Directory	Allows you to view the directory of a specified drive or change to a desired new directory (see previous section of this chapter for detailed description).

Quit	Interrupts the current operation and returns to the previous menu level. At the main menu level, this option exits the Terrasys program.

The following paragraphs provide complete details for each menu item, including sample screens, with the exception of the **Directory** and **Quit** options which have been discussed in the previous section of this chapter.

TERMINAL MODE

By selecting **Terminal Mode**, you allow your computer to act as a terminal in communicating serially with other computers, such as the AquiStar. After selecting **Terminal Mode** from the **Terracom** menu, the upper right hand corner of your screen will show the message "Terminal Mode". From here, you can work with PGM3 to program the configuration of your data logger and start the data collection tasks you wish to perform. For details, refer to Chapter V, Working with PGM3.

Prior to entering terminal mode, you must verify that the communications parameters of your computer are set as required. To check or change any of these parameters, refer to the description of the **Change Baud Rate** menu option later in this section. A step-by-step guide for this task is also provided in Chapter III, Getting Started. After entering terminal mode, all characters received are displayed on the screen. Any characters typed at the keyboard (except <ESC>) are transmitted through the selected COM port using the specified communications parameters.

By pressing the <ESC> key, you can exit from terminal mode at any time and return to the **Terracom** menu.

INSTALL PROGRAM

This menu option allows you to download a Terrabasic program from diskette to the data logger. If, for example, your data logger does not have PGM3 installed in RAM, you could use the **Install Program** option to download PGM3 into your AquiStar's memory. Prior to the installation process, however, you must insure that the communications parameters on your computer are set appropriately to enable communication with your data logger. See Chapter III, Getting Started, or the next menu option in this section for details on setting communications parameters.

In order to download a program via the **Install Option**, follow these steps:

1. From the **Terracom** menu, select the **Terminal Mode** option. Your screen will indicate "Terminal Mode" in the upper right hand corner.

2. Wake the data logger by pressing <SHIFT>+<C>. If a menu appears, press <CTRL>+<A> to get a prompt. If "C" characters are displayed on the screen, press <ENTER> to get the prompt.

3. At the Terrabasic prompt (>), type **New** and press <ENTER>. Then press the <ESC> key to return to the **Terracom** menu.

4. Select the **Install Program** option. The top window of your screen will now prompt you for the filename of the program.

5. Insert the diskette which contains the program to be downloaded into Drive A of your computer and type the filename at the prompt (e.g. "A:\PGM3"). Be sure to include the correct drive and directory, if any. After supplying the filename, press <ENTER>. The system will carry out a basic verification routine to insure that the specified filename is a valid program, and you will receive a message on the screen, advising you of the number of lines in the program (e.g. "102 lines processed").

6. Press any key to begin installation of the program. The screen will display every line of the program as it is being installed in your data logger. When installation is complete, you will be prompted to press any key to return to the **Terracom** menu.

CHANGE BAUD RATE

This menu option allows you to change the communications parameters of your computer in order to make them compatible with the AquiStar. When you select the **Change Baud Rate** option, the communications parameter screen is displayed on your terminal as shown in Figure 6.5.

```
        Current Baud Rate       com1:1220,n,8,1,on      Echo --->  off

Port                    Com1:       Com2:

Baud Rate               300         1200        2400        4800        9600

Parity                  None        Odd         Even

Word Length             7           8

Stop Bits               1           2

Xon/Xoff                On          Off

Echo                    On          Off


Change Setup --->  Use Arrow Keys   Accept Changes --->  Use Enter Key
                 Escape --->  Use ESC Key
```

Figure 6.5 Change Baud Rate Screen

The top window of the screen indicates the current settings, which are also highlighted in the select fields below the window. To change any of these parameters, move to the desired line by using the <UP> or <DOWN> arrow key. Use the <LEFT> or <RIGHT> arrow key to make the appropriate selection. The chosen value will stay selected as you move on to the next line. When all lines show the correct values, press the <ENTER> key.

The following list contains a brief description of these communications parameters and indicates which values are to be used for communication with the AquiStar DL-1 or DL-1A.

Port - Either COM1 or COM2 may be selected. The default value is COM1. If you have more than one serial port on your computer system, you have to determine which is to be connected to the AquiStar and make the selection in this field accordingly.

Baud Rate - The baud rate represents the speed at which data is being transferred. Five choices are available: 300, 1200, 2400, 4800, and 9600. For communication with the AquiStar DL-1 or DL-1A, this parameter must be set at 1200.

Parity - Three choices are available in this field: none, even, or odd. For communication with the AquiStar, you must select "none" for this parameter.

Word Length - Word length represents the number of data bits per word. The available options are 7 or 8. For communication with the AquiStar, you must select 8.

Stop Bits - The number of stop bits to be used can be set to either 1 or 2. Select 1 for use with the AquiStar.

Xon/Xoff - This parameter allows the user to choose whether or not to use the Xon/Xoff handshaking protocol. The options are On or Off. If this protocol is enabled (On) and the sending system also supports Xon/Xoff, nothing except the size of the receiving disk drive will limit the size of the communications file that can be saved to disk. For communication with the AquiStar DL-1 or DL-1A, this protocol must be enabled (On).

Echo - This field allows the user to select full or half duplex operation. Available options are On or Off. If echo is set to On, characters typed at the keyboard will be echoed locally for screen display. This is called half duplex operation. If echo is set to Off, typed characters will not be echoed to the screen by the terminal emulation program. This implies that the computer you are connected to, such as the AquiStar, will echo back each character as it receives it. For communication with the AquiStar, the value Off should be used.

THE TERRAVUE MAIN MENU (VIEW DATA FILE)

The **Terravue** main menu as shown in Figure 6.6 is displayed when you select the option **View Data File** from the main Terrasys menu. It incorporates all the functions necessary to view the collected data in their entirety or in selected segments, to compute average data values by defining an averaging interval, and to print the collected data or prepare a spreadsheet compatible file.

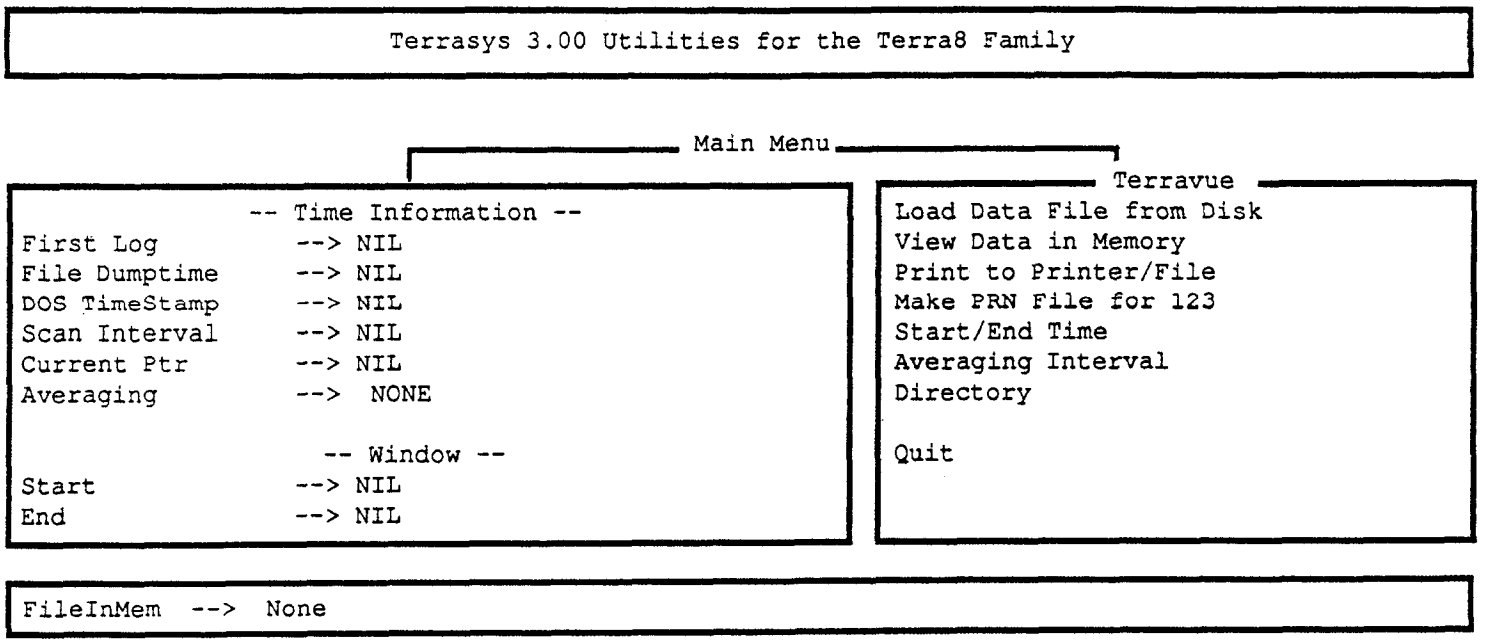

Figure 6.6 Terravue Main Menu Screen

To the left of the main menu, the screen displays information about the data file. Until a file is actually loaded from disk into active memory, the values for each of these information fields remain blank.

The table below provides an overview of the basic functions of each menu item in the **Terravue** menu. Some of the menu options will in turn produce other submenus.

Menu Option	Purpose
Load Data File from Disk	Loads a file that has been uploaded from the data logger and stored on disk into active memory to be viewed, manipulated or printed. This option must be selected before any of the other menu items become available.
View Data in Memory	Lets you browse through the data file in the same manner as if you were examining it in the memory of the data logger before uploading the data (similar to the **Examine** option in the **Data** menu of PGM3; see Chapter V, Working with PGM3).
Print to Printer/File	Allows you to produce formatted printouts of the data to either a printer or disk file. Data, including date/timestamps, can be selectively printed from any or all channels.
Make PRN File for 123	Lets you produce a Lotus 1-2-3 compatible plotter file for export into the popular spreadsheet program.
Start/End Time	Defines a user-selected window of data that is to be viewed, printed or processed.

Averaging Interval	Allows you to process the data in active memory to be displayed or printed as average values over selected intervals. When viewing the data after selecting an averaging interval, you will see an "A" placed next to each data value.
Directory	Lets you view the file directory of a specified drive as described earlier in this chapter.
Quit	Interrupts your current action and takes you one step back in the program or exits the program.

The following paragraphs provide a detailed description of each of the above menu items, including possible submenus. Sample screens are provided for clarification.

> **Note** Some information in this section, as it relates to channels, will not be applicable to the AquiStar DL-1 or DL-1A. Terrasys is designed to work with both single and multi-channel data loggers, therefore, certain screen displays will relate to multi-channel loggers. The additional information has been included for clarity's sake only, since you will see it on your screen.

LOAD DATA FILE FROM DISK

As mentioned in the above table, this menu option must be selected before any of the other menu items become available. If you choose any other option, a message will appear on the screen indicating that no file is in memory. Pressing any key will take you back to the main Terravue menu.

To load a data file into active memory, simply select the option **Load Data File From Disk** and type the desired filename in the top window of the screen. If the file is not located on the default drive, edit the path accordingly.

> **Note** Data files are read into memory in 8 kilobyte blocks. If the file is smaller than 8K, the entire file is read into memory, and the message "File Loaded" appears on the screen. If the file size exceeds 8K, the screen will display the message "File Partially Loaded". The remainder of the file will automatically be loaded into memory when you have reached the end of the first 8K block while viewing or printing the data.

You may see a "Checksum Error" message appear while loading a data file. This could indicate a problem with a corrupt data file. Checksum errors typically occur because the program assumes that any line containing a colon (:) symbol is in Intel Hex format, which frequently is not the case. For example, while loading the first section of the data file containing timestamp data, which contains colons, you will usually see the "Checksum Error" message appear. In these situations, there is no problem with the data, and the message can be disregarded.

If, however, you are loading a section of data file containing only data, the "Checksum Error" message may be indicating a problem with the data block, such as a missing value. In this case, check the data carefully to see if it appears reasonable. You can view the .hex data file directly using the DOS command **Type** or **More**. The main block of data values should have a uniform appearance when displayed on the screen, i.e. the same number of rows and columns. Any missing values are an indication that the data may be corrupt.

Once the data file has been loaded into memory, **Terravue** reads the header information of the file and updates the heretofore blank time and scan interval information on the left side of the screen to reflect the current file. The bottom window of the screen displays the name of the file in memory. An example of this screen is provided in Figure 6.7 below.

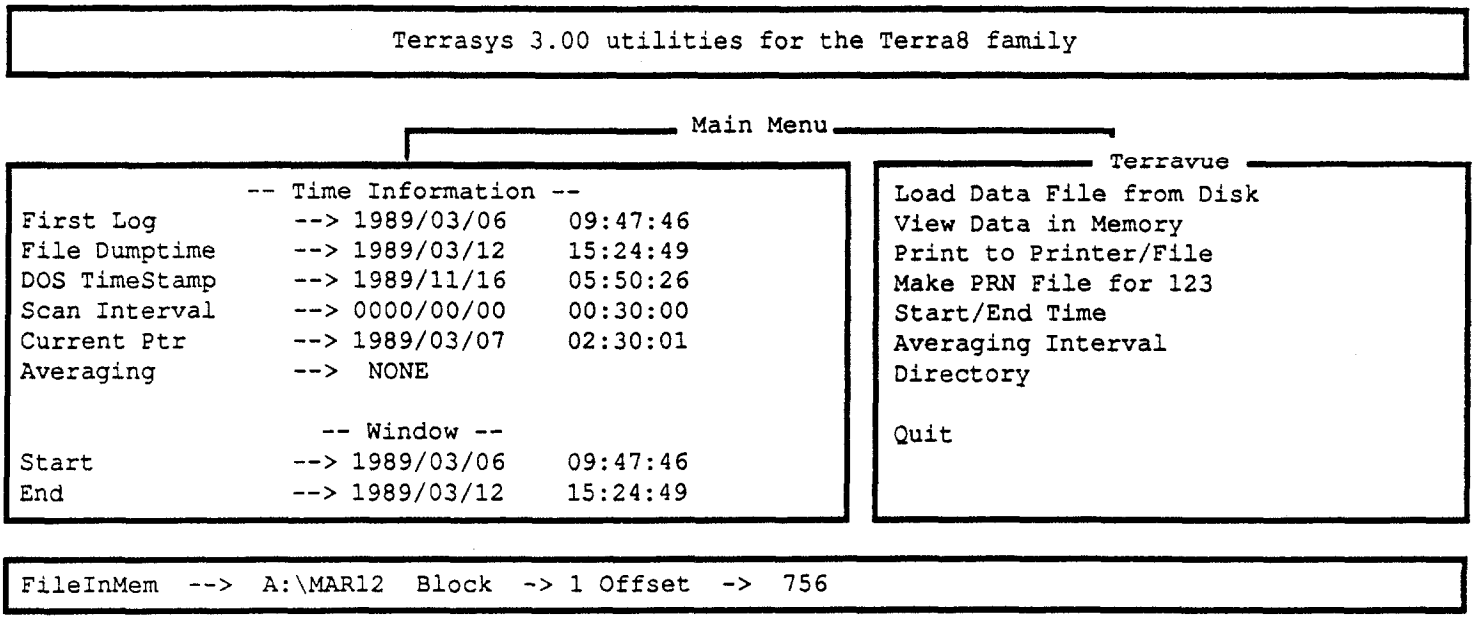

Figure 6.7 Terravue Menu Screen

VIEW DATA IN MEMORY

Selection of this menu option will result in the **View** submenu appearing on the screen as shown in Figure 6.8. In addition to the **Quit** option, four choices are available at this level.

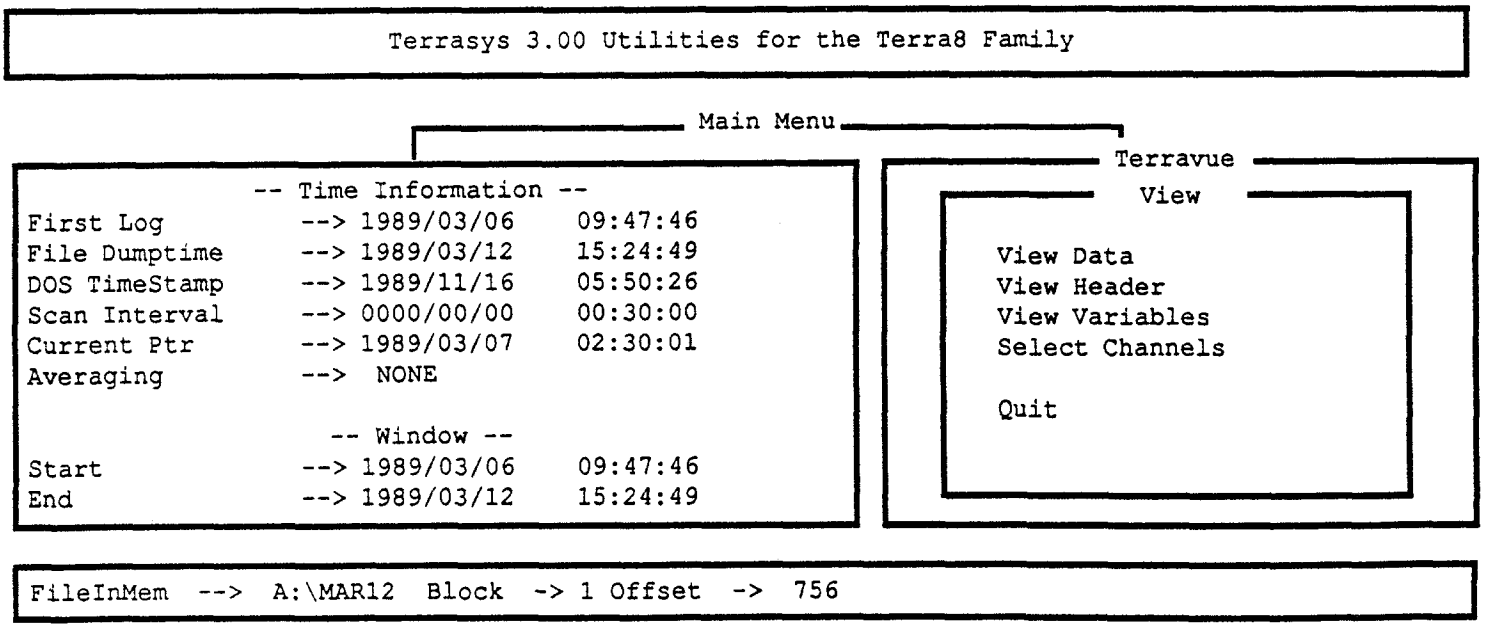

Figure 6.8 Terravue View Menu

For practical reasons, the order in which these menu choices are discussed does not correspond to the order in which they are listed on the menu.

Select Channels

For data files originating from the AquiStar DL-1 or DL-1A, analog channel number 01 will already be selected by default, and the selection process can be omitted, unless the channel has been deselected manually.

For multi-channel data loggers, you can designate the data you wish to display. The program selects all channels by default; if you wish to see only certain channels, you must deselect the ones you want to omit from display. To do so, choose the **Select Channels** option from the **View** menu. Your screen will display a listing of all analog channels (indicated by the word "Analog" in the top window) as shown in Figure 6.9 below.

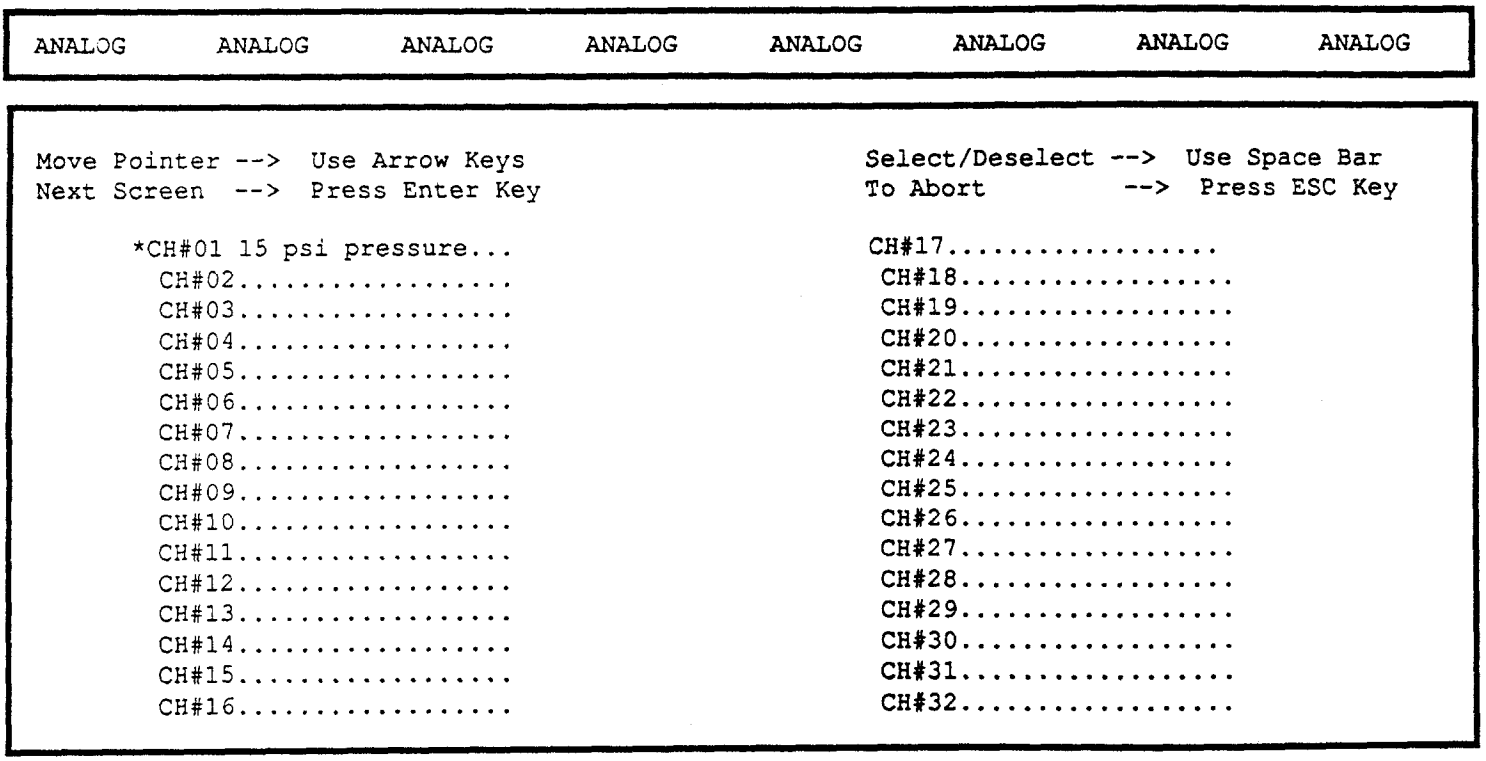

Figure 6.9 Analog Channels Selection Screen

To move through the list of channels, use the arrow keys. By pressing the <SPACEBAR>, you can select or deselect a particular channel for which you wish to display data. An asterisk will be placed next to each selected channel. When all desired analog channels have been selected, press the <ENTER> key to go to the next screen, which will present a list of digital channels. The selection process is identical to that for analog channels. Pressing <ENTER> after selection is complete will bring the **View** menu back to the screen.

View Data

When you choose this menu option after selecting one or more channels, the screen will display the first log, including date and timestamp, for the appropriate channel(s). Figure 6.10 provides a sample display of the View Data Screen.

Date	Time	15 psi pres ft.....
1989/03/06	15:30:01	5.1797E+01
1989/03/06	16:00:01	5.1797E+01
1989/03/06	16:30:01	5.1808E+01
1989/03/06	17:00:01	5.1819E+01
1989/03/06	17:30:01	5.1819E+01
1989/03/06	18:00:01	5.1819E+01
1989/03/06	18:30:01	5.1819E+01
1989/03/06	19:00:01	5.1808E+01
1989/03/06	19:30:01	5.1808E+01
1989/03/06	20:00:01	5.1808E+01
1989/03/06	20:30:01	5.1808E+01
1989/03/06	21:00:01	5.1797E+01
1989/03/06	21:30:01	5.1797E+01
1989/03/06	22:00:01	5.1776E+01
1989/03/06	22:30:01	5.1765E+01
1989/03/06	23:00:01	5.1754E+01
1989/03/06	23:30:01	5.1743E+01
1989/03/07	00:00:01	5.1721E+01
1989/03/07	00:30:01	5.1711E+01
1989/03/07	01:00:01	5.1711E+01

Figure 6.10 View Data Screen

Note that the top window of the screen shows the descriptions and display units for each of the selected channels. The scanning interval is shown below the first log in the main window. To see the next log, simply press the <ENTER> key or <SPACEBAR>. Keeping the <SPACEBAR> pressed down will result in the data file scrolling across the screen.

The program will use the log timestamps where present in the file or calculate them from the start time and scan interval. If the time is calculated, the display will show the letter "C" next to the time. If the data is averaged over a selected time interval (see the **Averaging Interval** menu option later in this chapter), the letter "A" will appear next to the timestamp. Should an erroneous timestamp (i.e. an invalid time) be encountered, the time will be displayed on the screen with an exclamation mark (!) next to it. The data values displayed have been converted from raw data to engineering units by using the conversion multiplier and offset as specified in the channel information during the data logger set-up.

> **Note** Erroneous calculated times can appear if variable scan intervals are set up and the logs/timestamp parameter is not set to 1.

View Header

When you select **View Header** from the **View** menu, the program will display a screen containing the information found in the data file header block, as shown in Figure 6.11.

```
                Terrasys 3.00 Utilites for the Terra8 Family

                        Terra8 Data Collection Report

Firmware Version                7.1/87
Number of Bytes in Data Dump      3409
User Supplied Comment
Time Header Block Loaded        1989/03/06  09:47:46.80
Time Data File Dumped           1989/03/12  15:24:49.20
Remaining Memory                   21167
Number of Logs                       296
Type of Data Memory             Main Memory
Logs/Timestamp                  1
Power was OK During Data Collection Period

<AnyKey>
```

Figure 6.11 View Header Screen

This screen allows you to verify how many bytes and logs are contained in the file, the date and time the first header block was loaded, the date and time the file was dumped, the amount of remaining memory in the data logger at the time of the data dump, the type of data memory, and the frequency of timestamp information. To get back to the **View** menu, press any key.

> **Note** A data file can contain many different header blocks, if your file includes data from several tests that have been carried out with different set-up configurations. But in viewing the header information, you will only see the time at which the first header block was loaded into the workspace. During viewing or printing of the data, new header blocks will be indicated by the message "Z Variable Block Encountered", followed by the first log taken under a new set-up and the new scanning interval.

View Variables

This option allows you to display the channel set-up variables as they were specified in the data logger set-up. When you select **View Variables** from the **View** submenu, a screen similar to the one in Figure 6.12 will be displayed, showing the channel set-up parameters for each analog channel (only one channel will be displayed for the AquiStar DL-1 or DL-1A).

```
                                Terra8 Channel Setup

Number of ANALOG Channels = 1
-------------------------------------------------------------------------------
_Ch#___Description_____Units___Delay_________M_____________________________B_____

  1 15 psi pressure...  ft.......   100      -8.6625E+0000  8.0600E+0001
<AnyKey>
```

Figure 6.12 View Variables Screen

The listing of this information differs slightly from the format in which it is specified during the data logger set-up:

Description = channel description.

Units = display units.

Delay = warm-up time.

M = conversion multiplier.

B = offset.

> **Note** If you wish to review variables for set-ups subsequent to the initial configuration, you can do so by viewing data until you see the message "Z Variable Block Encountered". Immediately after this message, press <ESC> and select **View Variables** from the **View** menu. The screen will then display the variables for the portion of data that is following the message. To return to viewing data, you must start over by selecting **View Data** and start the review from the beginning.

While viewing variables, you can move to the next screen by pressing <ENTER>. The next screen will display the same information for all digital channels.

PRINT TO PRINTER/FILE

The **Terravue** menu provides this option to allow users to print collected data to either a printer or a disk file. The disk file could then be printed later using the DOS **Print** command. In addition to printing out data, it is also possible to print out header block and channel set-up information. The menu options provided for these tasks function in the same manner as in the previously discussed **View** menu.

When you first select **Print to Printer/File** from the **Terravue** main menu, the program will present a submenu prompting you to choose a device, i.e. **Printer** or **File**. If you select the **File** option, the upper window of the screen will prompt you for a filename by displaying a default drive and filename. You can accept this file by simply pressing <ENTER> or type a new filename, including the correct drive, and press <ENTER>. A window across the top of the main menu will now display a message indicating that a printer file is open. Pressing any key will bring up the **Printer** menu as shown in Figure 6.13. By selecting the **Printer** option when prompted to choose a device, you will immediately see the **Printer** menu displayed. In this case, you need to insure that your printer is online and ready to print, and that paper is loaded and aligned to the top of the form.

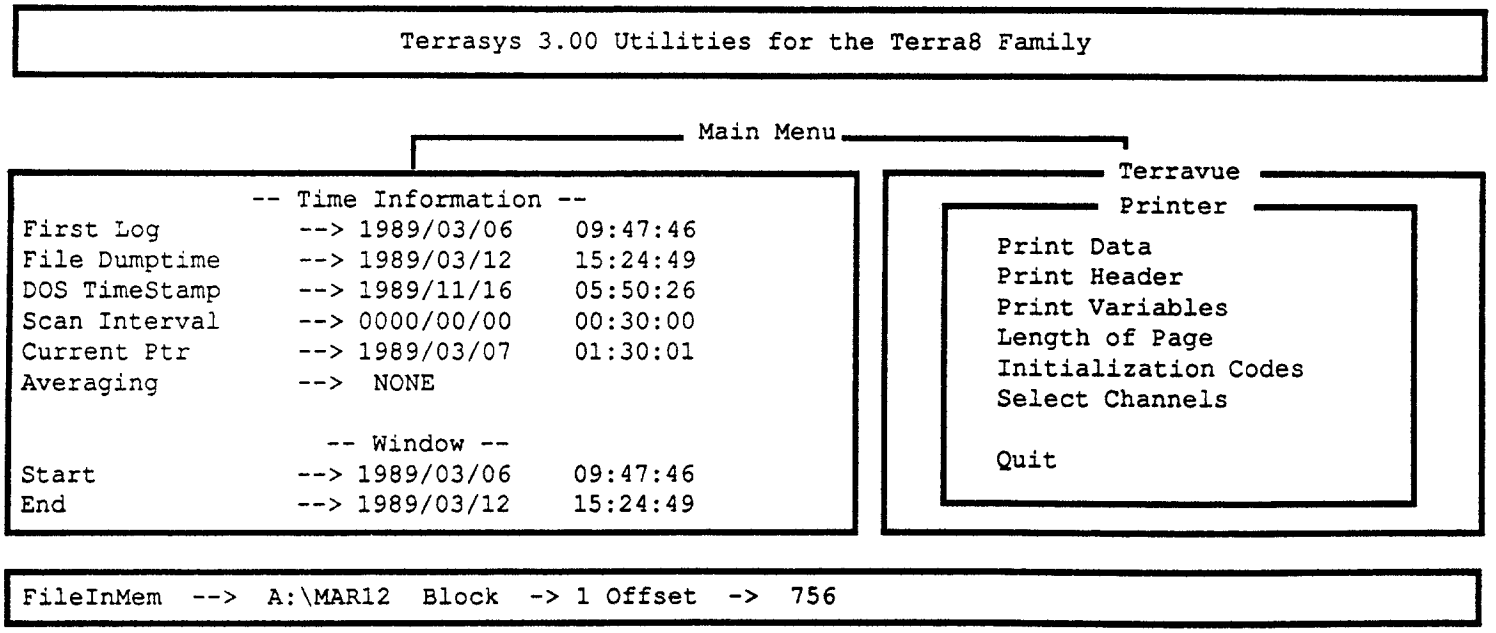

Figure 6.13 Terravue Printer Menu Screen

The choices available at this point are the same for data output to a file as they are for output to a printer.

The program allows a limited number of printer set-up options, such as **Length of Page** and **Initialization Codes**. If you want to use these options, they must be chosen before any of the other print options are selected. Therefore, they are listed here in a different order than in the Printer submenu.

Length of Page

This option allows you to specify how many lines per page you wish to print. The default value is 60, which normally fits on a standard 8.5 x 11 inch page. This value will be displayed when you select **Length of Page**. You can accept it by pressing <ENTER> or type in the desired value and press <ENTER>. The program then returns to the **Printer** menu.

Initialization Codes

This menu option lets you send a set-up code to the printer before starting to print data. The set-up codes must be specified as valid ASCII codes in the following format:

\xxx\xxx\xxx\xxx\xxx

where *xxx* represents the code to be supplied by the user.

Up to five codes may be sent. Legal ASCII codes range from 0 to 255 and are printer specific. For example, sending ASCII code 015 to most standard IBM printers results in compressed print. Consult your printer manual for appropriate software codes.

Select Channels

Just as for viewing data, you can select the data you wish to print by selecting the desired channels. By default, all channels are selected. When you choose **Select Channels** from the **Printer** menu, your screen will display the list of analog channels as shown in Figure 6.14.

```
ANALOG    ANALOG    ANALOG    ANALOG    ANALOG    ANALOG    ANALOG    ANALOG
```

```
Move Pointer -->  Use Arrow Keys                  Select/Deselect -->  Use Space Bar
Next Screen  -->  Press Enter Key                 To Abort         -->  Press ESC Key

      *CH#01 5 PSI PRESSURE...                    CH#17.................
       CH#02.................                      CH#18.................
       CH#03.................                      CH#19.................
       CH#04.................                      CH#20.................
       CH#05.................                      CH#21.................
       CH#06.................                      CH#22.................
       CH#07.................                      CH#23.................
       CH#08.................                      CH#24.................
       CH#09.................                      CH#25.................
       CH#10.................                      CH#26.................
       CH#11.................                      CH#27.................
       CH#12.................                      CH#28.................
       CH#13.................                      CH#29.................
       CH#14.................                      CH#30.................
       CH#15.................                      CH#31.................
       CH#16.................                      CH#32.................
```

Figure 6.14 Analog Channels Print Selection Screen

The selection procedure is identical to the one used in selecting channels to be viewed. You move through the list of channels using the arrow keys. Pressing the <SPACEBAR> will select or deselect a particular channel. An asterisk is placed next to a channel which has been selected for printing. After selecting all desired analog channels, press <ENTER> to go to the next screen and repeat the channel selection process for all desired digital channels.

> **Note** For data files originating from single-channel data loggers, analog channel number 1 must be selected, or no data will be printed.

The program expects you to select only the number of channels that your printer can print on one line. If you select more channels than can fit on one line, the printer will "wrap" the remaining channels down to the next line. This will result in a hard-to-read printout, as well as cause page breaks to occur in the wrong place.

If your printer is set for 80 columns per line, five channels can be printed; 128 columns per line can accomodate eleven channels. Compressed print mode may provide a way to include additional channels per line.

Print Header

This menu option is almost identical to the **View Header** option in the **View** submenu, except that it prints the data file header block when selected. At the same time, it will be displayed on the screen.

Print Variables

This option will print the channel set-up information for selected channels. The information is simultaneously displayed on your screen. However, while the screen shows all channels in the data file, only the selected channels are printed.

Print Data

This menu option allows you to print all data for selected channels. While being sent to the printer, the data will be displayed on your screen in continuous scroll mode. Again, the screen will show all channels, whereas only the selected channels are printed out.

MAKE PRN FILE FOR 123

This option is designed to afford you access to the sophisticated data manipulation and graphing features, as well as peripheral support (such as new printer types) offered by Lotus 1-2-3 and other compatible spreadsheet programs so that your data can be processed into an impressive, high quality report. Terrasys provides a routine which allows you to convert your data files into Lotus 1-2-3 compatible .prn files, which can then be imported into Lotus using the Lotus command / File Import Numbers.

When you choose the option **Make PRN File for 123** from the **Terravue** menu, the program will prompt you to supply a filename for the Lotus compatible .prn file. The filename must have the .prn extension in order to be recognized by Lotus 1-2-3 as an importable file, therefore, the program will automatically assign this file extension.

> **Note** Some other spreadsheet programs will also accept the .prn file extension for an importable file. To be certain, check your manual and use the file extension specified by your particular spreadsheet program.

The filename for your .prn file must not exceed six (6) characters in order to allow for the breaking up of long data files into appropriately sized segments. Lotus 1-2-3 limits import file length to 2048 lines (or 8192 for later versions), but your data file may be much longer. Terrasys automatically breaks longer files into segments of appropriate length and appends a two-digit number to your filename to designate sections of the same data file.

Example: You supplied the 6-character filename "P-Test" for your data file, which contains more records than the Lotus 1-2-3 import file will allow. Terrasys will break this file into three separate output files and save them as follows:

P-Test01.Prn
P-Test02.Prn
P-Test03.Prn

After you supply the filename (including the appropriate drive), the program will display the message "Plotter File Open - <AnyKey>". Pressing any key will then display the submenu **Make PRN**, which presents the following choices:

Write Data
Write Header
Write Variables
Length of Spreadsheet
Select Channels
Cell Separator

The first three options are identical to the ones previously discussed in the **Printer** submenu, except that they will write the data, header or variables to the Lotus compatible file rather than printing them. Before selecting these options, you may wish to specify the spreadsheet length, the cell separator and the channels from which you wish to include data, unless you know that the default values for those options will serve your purpose.

Length of Spreadsheet

When you select this menu option, which allows you to specify the desired spreadsheet length, the program will prompt you to indicate the length in lines. The displayed default value is 20000. Older versions of Lotus 1-2-3 had a default value of 2000 lines.

Cell Separator

The *cell separator* is an ASCII code that designates the character inserted between data values during the conversion of data to individual spreadsheet cells. Lotus 1-2-3 uses a space (ASCII code 32) as cell separator. Other spreadsheet programs may use different characters. The menu option **Cell Separator** allows you to specify the ASCII code used by your particular spreadsheet program to define the cell separator. You will be prompted to insert the appropriate ASCII code. The default value is the Lotus 1-2-3 compatible ASCII code for a space (32). Consult the manual for your spreadsheet software to find the appropriate ASCII code for the cell separator used by your particular software.

Select Channels

Lotus 1-2-3 permits a maximum of 240 characters per line of an import file. This presents no problem for an AquiStar DL-1 or DL-1A, and you can ignore this menu option if you work with a single-channel data logger. However, if you have a multi-channel data logger with a large amount of channels, you may exceed this limitation. In this case, use the option **Select Channels** to break the data file into two or more output files. The selection process operates in the same way as it does for selecting channels to be viewed. First, you select all desired analog channels to be included in the plotter file. Use the arrow keys to move through the list of channels and the <SPACEBAR> to select or deselect a channel. Press <ENTER> to repeat the selection process for digital channels. Press <ENTER> again to return to the **Make PRN** submenu.

Appendix C of this manual contains instructions on how to import a .prn file into Lotus 1-2-3.

START/END TIME

The **Start/End Time** option of the **Terravue** main menu allows you to reduce the amount of data to be viewed or printed by using start and end times to define a data window. When you select this option, the program prompts you to type in a valid start time, which must be within the time interval covered by the entire data block. The default start time is the beginning of the logging period. Next, you are prompted to specify a valid end time, which must also fall within the time period covered by the data. The default end time is the end of the logging period.

The program will check the specified times for validity and then update the start/end times displayed under the heading "Window" on the left side of the **Terravue** menu screen. Figure 6.15 shows a sample of this display.

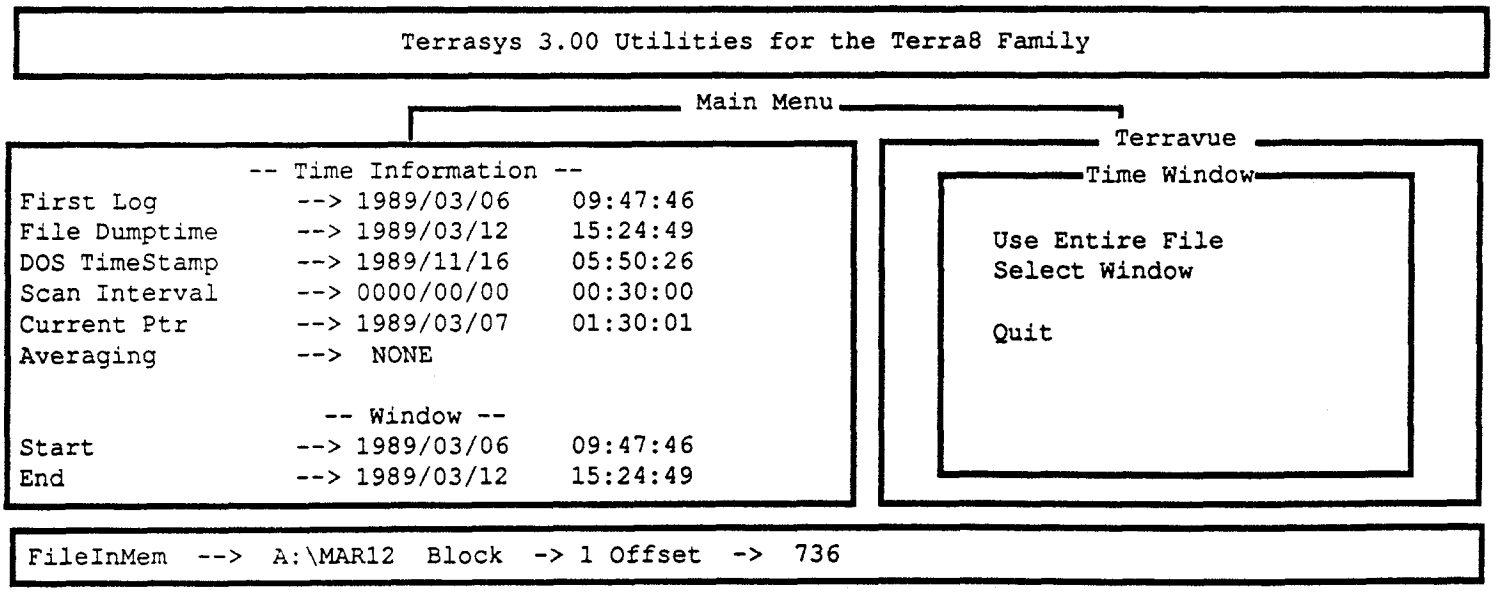

Figure 6.15 Data Window Defined on Terravue Menu

All other **Terravue** viewing and printing options will then be valid only for the "window" of data selected. To view or print the entire file again, redefine the start/end time using the full data collection period.

AVERAGING INTERVAL

This menu option allows users to average data for each channel over a specified time interval. By selecting **Averaging Interval** from the **Terravue** main menu, you display the **Average** submenu shown in Figure 6.16. Averaged data can be computed for any of the intervals shown, including **All** data in the file. Move the highlight to the desired averaging interval and press <ENTER>. The program will return to the **Terravue** main menu.

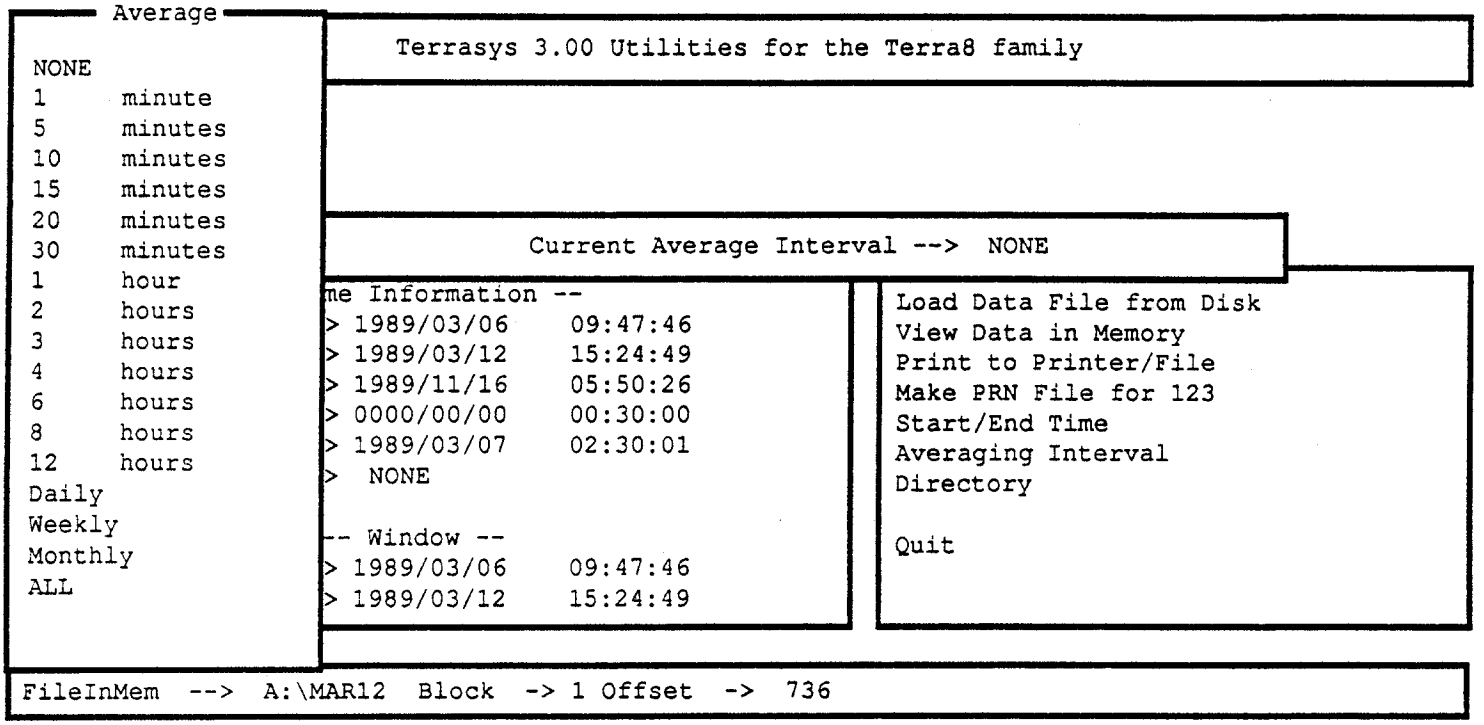

Figure 6.16 Average Menu Screen

Selecting an averaging interval will cause one average reading to be displayed for all logs contained within the averaging interval.

Example: Your data has been logged every 30 seconds, and you choose an averaging interval of 1 hour when viewing the data. The screen will display one average value for every 120 logs taken.

> **Note** Data logs that are averaged will be marked by an "A" to distinguish them from real-time logs.

VII MAINTAINING THE AQUISTAR

The AquiStar is a self-contained, compact unit that requires very little maintenance other than regular battery checks. Provided you keep the data logger as clean as possible and away from physical hazards, such as immersion in water, you will enjoy reliable performance of your AquiStar for a long time to come. This chapter provides information regarding battery maintenance, storage of the data logger, and shipping considerations.

BATTERIES

The AquiStar DL-1 or DL-1A is equipped with two batteries. The main power source is a 6-volt sealed lead acid cell of 2.6 AH capacity that is immediately visible, when the data logger enclosure is opened. Back-up power for the memory and real-time clock is provided by a 3-volt lithium battery that is mounted on the circuit board.

> **Important** Proper operation of the AquiStar will only occur with supply voltages from 6.0 to 7.0 volts. Do not attempt to use a 12-volt battery, or damage will result!

The main battery should be recharged for every data collection period, especially if the unit is to remain in the field unattended for longer periods of time. Your distributor can supply 6-volt battery chargers specifically designed to charge the battery supplied with the data logger and guaranteed not to overcharge it.

The back-up battery should retain its charge for at least three (3) years. Since this battery insures that the AquiStar never loses power to its memory, it must be examined on a regular basis. We recommend that you check it at least every six (6) months. For reliability purposes, the lithium battery is soldered onto the circuit board. Therefore, it should only be replaced by qualified personnel. Please contact your distributor for replacement of your back-up battery.

If problems develop with your data logger, it is most likely due to an insufficiently charged or overcharged battery. You should purchase a good quality DMM or voltmeter to periodically verify that the batteries are fully charged. A fully charged 6-volt battery should sit at or above 6.3 volts. If it is below 6.1 volts, it should be recharged to insure proper operation of the data logger. The lithium battery should sit at or above 3.6 volts; below 3.0 volts replacement is necessary.

Most people find it useful to purchase a battery charger and a spare main battery with the data logger, thus insuring the availability of one fully charged main battery at all times.

> **Note** If the main battery is disconnected or insufficiently charged, the memory and real-time clock of the AquiStar are powered by the back-up battery. To avoid draining the lithium battery, the AquiStar should always be stored with the main battery connected.

STORING THE AQUISTAR

When storing the AquiStar, you should first put it into sleep mode to conserve battery power. However, if you inadvertently leave it in wake mode, the AquiStar's unique timeout feature will automatically put the unit into sleep mode if three (3) minutes pass without any commands being received.

Since the AquiStar consumes battery power even when not in use, it is important to insure that the main battery is connected and charged before storing the unit. While in storage, the data logger's main battery should be checked monthly and recharged at least every three (3) months. An easy way to perform the battery maintenance is to keep a spare main battery connected to the charger at all times and simply exchange batteries on a regular basis.

> **Note** Remember that you will drain the lithium battery if the main battery is not functioning!

SHIPPING CONSIDERATIONS

When shipping the AquiStar, you should always use the original packaging material and insure that the unit is well protected.

AquiStar data loggers are approved for all forms of air travel, and no special DOT (Department of Transportation) documents are required for shipment by commercial carriers.

> **Note** Occasionally, X-rays or strong radio transmissions may interfere with the data logger's operating program. When this happens, it may be necessary to reinstall the operating program from EPROM or diskette.

VIII TROUBLE SHOOTING

With proper handling and regular battery maintenance, the AquiStar will demonstrate excellent performance throughout its lifetime. If problems do occur, they are usually minor and often caused by a simple error or oversight. In most instances, the user can resolve these types of problems very quickly and without assistance by simply checking his or her own actions. Listed below are some of the more common problems encountered and the steps necessary to resolve them.

Problem: **LED Will Not Light Up**

Solution: Verify that the serial cable is securely attached to the AquiStar and to the proper port of your computer terminal.

Verify that you are using a straight-through RS232C cable and not a null modem cable.

Check to insure that the main battery is fully charged.

Problem: **LED Lights Up But No Menu Appears On Screen**

Solution: Check the RS232C cabling and insure that all connections are secure.

Verify that the terminal's communications parameters are set appropriately (see Chapter III, Getting Started).

The <CAPS LOCK> key on your keyboard could be "on". Turn it "off" and try waking the AquiStar again by pressing <SHIFT>+<C>.

Problem: **Sudden Communication Failure**

Solution: You may have accidentally pressed <CTRL>+<S>, which stops the serial data link. This is especially likely if you were trying to press <CTRL>+<A> to break the program execution. To resume communication, press <CTRL>+<Q>.

If all else fails, disconnect the main battery, then press the "Reset" button on the circuit board for 10 seconds. The "Reset" button is a small push-button located next to the lithium battery; disassembly of the unit is required to access this button. This measure should be used as a last resort only.

Caution! Pressing the "Reset" button will result in loss of data and program, since it resets all RAM memory.

Problem: **Screen Displays "Power Fail" Message**

Solution: The main battery of your data logger may have become discharged below a safe working voltage. After writing the message, the unit will go into sleep mode to conserve what little power is left, in order to preserve data memory. To correct the problem, replace the battery with a fully charged one and recharge the spare battery.

Problem: **Wrong Time Displayed/**
Program Lost During Battery Exchange

Solution: An incorrect time display, when the real-time clock has previously been set, is an indication that the lithium battery is failing. Loss of the program from memory during battery exchange indicates the same problem. See Chapter VII, Maintaining the AquiStar, for details about the back-up battery.

If you encounter problems that cannot be solved using these trouble shooting hints, or if you require help in running the software supplied with your AquiStar, contact your distributor or Instrumentation Northwest, Inc.

GLOSSARY

Baseline Interval A user-defined constant logging interval at which the AquiStar takes readings before switching to variable-interval logging at a predefined time. Can only be used in variable-rate logging routines.

BASIC A standard programming language.

Bootable Diskette A diskette that has the DOS system files on it and can be used to start (boot) the computer.

Cell Separator An ASCII code value that designates an end-of-column character which is inserted between the individual cells of a spreadsheet.

Configuration The way a computing device is set up. This includes both hardware and software.

Configure To set up a computing device to function and interact with designated peripheral equipment in a specific manner.

Conversion Multiplier The number used to convert the output of a sensor into engineering units.

Downloading Transferring a program from your computer into the workspace of the data logger.

Dumping Data Transferring data from the data logger to a diskette or hard disk on your computer.

EPROM Acronym for "Erasable Programmable Read-Only Memory". Contains a copy of the operating software of the AquiStar and cannot be altered by the user.

Log To take a reading from the sensor and record the data in memory.

Monitor To display sensor readings to the screen without logging.

Offset The number added to the product of the sensor output and the conversion multiplier in order to obtain specified engineering units.

Operating Software The program that controls the data logger functions (PGM3).

Path Contains the drive and, if applicable, subdirectory in which a file is located and, therefore, represents the "address" under which a computer looks for a specified filename.

RAM Acronym for "Random Access Memory". The data logger's active memory, in which programs and data are stored, and from which programs are run. See *Workspace.*

Select/Choose To specify a menu option by placing the highlight on it and pressing the <ENTER> key or typing the first character of the desired option and pressing the <ENTER> key.

Sleep Mode Low-power idle mode that conserves battery power during storage of the AquiStar. The AquiStar automatically goes into sleep mode between logs during data acquisition, and when no keyboard input has been received for 3 minutes. See *Timeout*.

Terminal Device A computer that provides a screen and keyboard.

Terminal Emulation Program Software that allows a computer to act as the terminal device for another computing device.

Terminal Mode The operating mode in which a computer, acting as terminal for another computer, is controlled by the second computer.

TERRABASIC An extension of the BASIC programming language containing functions specifically designed for data acquisition.

Timeout A unique AquiStar feature which automatically puts the data logger into the low-power sleep mode when no keyboard input has been received for 3 minutes.

Timestamp Insertion of the current date and time next to a data record during data acquisition.

Upload mode The mode which enables your computer to receive data or a program listing from the data logger.

Uploading Transferring data or a program listing from the memory of the data logger to a diskette or hard disk on your computer.

Wake Mode Active mode in which the AquiStar performs all tasks. See *Sleep Mode, Timeout*.

Warm-Up Time The delay between applying excitation to the sensor and taking a reading from the sensor. Used to insure stable sensor readings.

Workspace The part of the data logger's RAM that stores the program, and from which the program is run. See *RAM*.

APPENDIX A - HELPFUL TERRABASIC INFORMATION

Appendix A provides some general information about the TERRABASIC interpreter, including a few essential TERRABASIC commands, a list of error messages, and a complete PGM3 program listing. A sample data file in Intel Hex format has also been included for illustration purposes.

ESSENTIAL TERRABASIC COMMANDS

As mentioned in the preface of this manual, some situations may require the user to work with certain TERRABASIC commands. These commands are:

Cold
DDIR
List
Load
New
Run

The use of the **Load** and **Run** commands has been discussed in Chapter III, Getting Started, in the context of loading PGM3 from EPROM. You may remember the **List** command from Chapter VI, Working with Terrasys 3.0, where it was used to upload a program listing to disk. The **New** command was also used in Chapter VI in describing the process of downloading or installing a program from disk.

Following is a general description of each command as used in TERRABASIC:

The Cold Command

Purpose: To reset all TERRABASIC pointers and flags to their initial state.

Syntax: **Cold**

Comments: The **Cold** command resets all TERRABASIC pointers, blocks, flags and devices except the real-time clock. Therefore, after execution of the **Cold** command, all TERRABASIC variables, the current program, and data are cleared. When the **Cold** command is issued, TERRABASIC prompts for confirmation:

"Are you sure?"

If any other answer than "YES" (in capital letters!) is received, TERRABASIC aborts the execution of the command.

The DDIR command

Purpose: To display the directory of EPROM based TERRABASIC program files.

Syntax: **DDIR**

Comments: The **DDIR** command is issued to find out which program is burned into EPROM. If no file is present, a directory error message is displayed.

The List Command

Purpose: To list all or part of the program currently in the TERRABASIC workspace.

Syntax: **List** [*linenumber*][-[*linenumber*]][,*device*]

Comments: The **List** command is used to upload the program in active memory to disk. The bracketed command options can be disregarded for uploading a program via the Terrasys menus. Appropriate prompts guide the user through the process. For more experienced users, the command options allow for uploading part of a program by indicating starting and ending line numbers and designating a target device, such as screen, printer, or a filename.

The Load Command

Purpose: To load a TERRABASIC program file from the EPROM directory into the TERRABASIC workspace.

Syntax: **Load***"filename"*

Comments: The **Load** command searches for the specified filename in the EPROM directory and loads the program into the active memory. Note that the **Load** command has to be entered with quotation marks surrounding the filename. After being loaded, the program can be run, edited, or uploaded to disk.

If the specified file is not found, the message "File Not Found" or "Not Fnd" is displayed.

The New Command

Purpose: Deletes the program currently in active memory and clears all variables.

Syntax: **New**

Comments: The **New** command is used to delete the current program. Previously collected data is not affected by this action and will remain intact.

The Run Command

Purpose: To execute the program currently in memory.

Syntax: **Run**

Comments: The **Run** command executes the program currently in the workspace.

If the **Run** command is used immediately after set-up of the data logger, the set-up values will be reset to default values. If at least one log has been taken before the **Run** command is executed, set-up will remain intact.

TERRABASIC ERROR MESSAGES

Following is a list of TERRABASIC error messages that may appear on the screen. Experienced BASIC programmers will be able to resolve potential problems based on the meaning of these messages. Inexperienced users may require assistance from their distributor.

Error	Code	Message	Meaning
0	00h	NF	NEXT without FOR
2	02h	SN	SYNTAX error
4	04h	RG	RETURN without GOSUB
6	06h	OD	OUT of DATA (after READ)
8	08h	IC	ILLEGAL function call
10	0Ah	OV	OVERFLOW
12	0Ch	OM	OUT of MEMORY - no mem. avail.
14	0Eh	UL	UNDEFINED LINE number
16	10h	BS	BAD SUBSCRIPT - (after DEF)
18	12h	AE	ARRAY error - double def
20	14h	/Z	Divide by zero
22	16h	IF	INPUT FAILED - inp. from command line
24	18h	TM	TYPE MISMATCH
26	1Ah	OS	OUT of STRING space
28	1Ch	LS	LENGTH of STRING error

Error	Code	Message	Meaning
30	1Eh	ST	STRING expression TOO complex
32	20h	NC	NOT possible to CONTINUE
34	22h	NR	NO RESUME allowed
36	24h	RO	RESUME without error
43	2Bh	DD	DATA acq.system error
44	2Ch	DE	DIRECTORY error

PGM3 PROGRAM LISTING

The following is a complete line-by-line listing of the PGM3 program written in TERRABASIC. It has been provided for the convenience of experienced BASIC programmers who may wish to edit this program to suit their specific purposes.

```
1 'JAN90
2 CLEAR220:Q=20:DIMP(Q):DIMR(Q)
3 DATA 1,5,10,30,60,120,300,600,1200,2400
4 Z=0:Y$="Y":S$="":W=1:V=10:X=V:I=W:ZI$=MKI$(V):C=W:Z8%(Z)=W:Z8%(W)=W:Z1$(W)
="5PSI":Z2$(W)="FT":Z3%(W)=100:Z4!(W)=2.8875"ERROR"
5 L=90:T=NOTF:CLG(C):FORK=WTOV:READP(K):R(K)=V:NEXT:R(V)=100:IFFLG(LOG)>Z
THENGET(FLG(LOG))
6 GOSUB85
7 S=T:ONERRORGOTO95:A=Z:PRINT:INPUT(L)"1-Setup 2-Acquisition 3-Data 4-Monitor 5-
Sleep";A:ONAGOTO8,28,70,79,80:GOTO7
8 GOSUB85
9 ONERRORGOTO95:A=Z:PRINT:INPUT(L)"1-Time 2-Scan Interval 3-Logs/Tstamp 4-
Channel Info 5-Exit";A:ONAGOTO10,12,23,24:GOTO7
10 PRINT:PRINT"TIME IS: ";TIME$;:GOSUB27:ONAGOTO9,11:GOTO10
11 GOSUB97:IFETHEN9ELSESET$(T,T$):GOTO10
12 A=Z:ONERRORGOTO95:PRINT:INPUT(L)"1-Single Int. 2-Variable Int. 3-
Exit";A:ONAGOTO13,15:GOTO9
13 B=F:I=W:PRINT:PRINT"Sample Int: ";LEFT$(ZI$,15);:GOSUB27:ONAGOTO9,14:GOTO13
14 GOSUB22:IFETHEN12ELSEI=W:V=T#:ZI$=MKI$(T#):B=F:LOG(I):GOTO8
15 B=F:PRINT:PRINT"Baseline Int: ";LEFT$(ZI$,15);:GOSUB27:ONAGOTO17,16:GOTO9
16 GOSUB22:IFETHEN15ELSEIFT#=ZTHENPRINT:PRINT"ERROR - Interval must be
>0":GOTO15ELSEV=T#:ZI$=MKI$(T#):LOG(I):GOTO15
17 ONERRORGOTO95:I=X:PRINT:PRINT"Current intervals are:":PRINT:GOSUB88
18 PRINT:PRINT"Are these intervals";:GOSUB27:ONAGOTO8,19:GOTO18
19 PRINT:INPUT(L)"# of different intervals (1-
20)";X:IFX>QORX<WTHEN19ELSEI=X:FORK=WTOX:PRINT"VARIABLE INT. #";K
20 P(K)=Z:INPUT(L)"Period in seconds";P(K):IFP(K)<WTHEN20
21 R(K)=Z:INPUT(L)"# of logs";R(K):IFR(K)<WTHEN21ELSENEXT:GOTO8
22 ONERRORGOTO100:E=F:M#=Z:GOSUB98:RETURN
23 M=T:PRINT:INPUT(L)"LOGS/TIMESTAMP= (0-
```

```
255)";M:IFM<ZORM>255THEN23ELSEC=M:CLG(C):GOTO9
24 PRINT:PRINT"HIT ENTER TO ACCEPT, OR TYPE NEW VALUE":PRINT
25 GOSUB90:INPUT(L)"";Z1$(W):Z1$(W)=LEFT$(Z1$(W),18):GOSUB91:INPUT(L)"";
Z2$(W):Z2$(W)=LEFT$(Z2$(W),8):GOSUB92:INPUT(L)"";Z4!(W):GOSUB93:INPUT(L)"";Z5!
(W):GOSUB94:INPUT(L)"";Z3%(W):Z3%(W)=ABS(Z3%(W)):IFFLG(LOG)>ZTHENLOG(Z):
GOTO8ELSEGOTO8
27 D$=S$:INPUT(L)" - OK (Y/N)";D$:GOSUB82:RETURN
28 A=Z:ONERRORGOTO95:IFI=WTHENV=CVI(ZI$):PRINT:INPUT(L)"1-Normal 2-Delayed
Start 3-Single Scan 4-Exit";A:ONAGOTO30,40,60:GOTO7
29 IFC<>WTHENPRINT:PRINT"* Setting Logs/
Tstamp=1":C=W:CLG(C):GOTO29ELSEPRINT:INPUT(L)"1-Variable 2-Variable with Baseline
3-Single Scan 4-Exit";A:ONAGOTO52,40,60:GOTO7
30 S=T:ONERRORGOTO63:IFV<3THEN35ELSEGOSUB64:GOSUB61
31 GOSUB64:GOSUB65
32 GOSUB66
33 T$=TIME$:IFWAKE$>T$THEN34ELSEIFLEFT$(WAKE$,W)>=LEFT$(T$,W)THEN31
34 GOSUB68:GOSUB65:GOTO32
35 S=F:PRINT:PRINT"SCREEN AND SLEEP DISABLED - SPACE BAR TO STOP"
36 IFV<WTHENSCAN:LOG(R):IFINKEY$=S$THEN7ELSE36
37 GOSUB66:G=VAL(MID$(QT$,14,3)):IFINKEY$=S$THEN7
38 Y=VAL(MID$(TIME$,14,3)):IFY<GTHENY=Y+600
39 IFY-G<VTHEN38ELSE37
40 PRINT:PRINT"Desired Start Time-
":GOSUB97:IFETHEN28ELSEPRINT:F#=T#:F$=T$:M#=T#-
CVI(TIME$):IFM#<2678400ANDM#>ZTHENPRINT"Start in ";MKI$(M#)ELSEPRINT"* Warn-
ing - Start delay > 30 days"
41 IFI=WTHENSET$(W,T$):GOSUB61:GOSUB68:GOTO30:ELSEONERRORGOTO63:IFF#<CVI
(TIME$)THEN47
42 V=CVI(ZI$):GOSUB64:IFV<3THENS=F
43 GOSUB65:GOSUB66
44 IFF#=<CVI(WAKE$)ORF#<CVI(TIME$)THENIFF#>CVI(TIME$)+WTHENSET$(W,F$)
:GOSUB68:GOTO52:ELSE5
45 T$=TIME$:IFWAKE$>T$THEN46ELSEIFLEFT$(WAKE$,W)>=LEFT$(T$,W)THEN43
46 GOSUB68:GOTO43
47 GOSUB64:IFV<3THENS=F
48 GOSUB66:W#=CVI(WAKE$):W2$=MKT$(W#+V):W2#=CVI(W2$)
49 IFW2#<W#THENA#=CVI(TIME$):IFW2#<F#THENSET$(W,W2$):IFA#>W#ORA#+W<W2
#THEN45ELSE43ELSESET$(W,F$):IFA#>W#ORA#+W<F#THEN46ELSE43
50 SET$(W,W2$):T$=TIME$:IFW2$>TIME$THEN51ELSEIFLEFT$(W2$,W)>=LEFT$
(A$,W)THEN48
51 GOSUB68:GOTO48
52 IFBTHENINPUT(L)"Resume series? (Y/
N)";D$:GOSUB82:ONAGOSUB64:ONAGOTO55,53:GOTO29
53 B=T:O=W:P=Z:GOSUB64
54 V=P(O):IFV<3THENS=FELSES=T
55 GOSUB65:GOSUB66
56 T$=TIME$:IFWAKE$>T$THEN57ELSEIFLEFT$(WAKE$,W)>=LEFT$(T$,W)THEN58
57 GOSUB68
58 P=P+W:IFP<R(O)THEN55ELSEO=O+W:IFO<=ITHENP=Z:GOTO54
59 GOSUB66:B=F:SLEEP*:GOTO7
60 ONERRORGOTO63:CLG(C):S=T:GOSUB66:GOTO28
```

```
61 IFC=ZTHENA=ZELSEA=7/C
62 PRINT"Memory will be full ";MKT$(CVI(WAKE$)+INT(V*FLG(RMEM)/(3+A))):RETURN
63 PRINT:IFFLG(FULL)THENPRINT"ERROR - MEM
FULL":RESUME7:ELSEPRINTA$:RESUME7
64 SET$(W,TIME$):RETURN
65 SET$(W,MKT$(CVI(WAKE$)+V)):RETURN
66 SCAN:LOG(R):D=F:IFSTHENPRINT:PRINT"Log #";FLG(LOG);"
RMEM=";FLG(RMEM):LOG(S)
67 RETURN
68 IFSTHENPRINT"WAKE : ";WAKE$
69 SLEEP:IFNOTFLG(WAKE)THEN7ELSERETURN
70 PRINT:PRINT"Number of Logs:";TAB(Q);FLG(LOG);TAB(30);"Remaining
Memory:";TAB(47);FLG(RMEM)
71 A=Z:PRINT:INPUT(L)"1-Dump 2-Examine 3-Reset Memory 4-
Exit";A:ONAGOTO72,74,77,7:GOTO70
72 IFFLG(LOG)=ZTHENPRINT:PRINT"NO DATA":GOTO7
73 D$="":PRINT:INPUT(L)"PRESS <ESC> TO SET UPLOAD. PRESS <ENTER> WHEN
UPLOAD MODE MESSAGE APPEARS IN UPPER RIGHT CORNER OF
SCREEN";D$:IFD$<>""THEN70ELSEDUMP(D):D=T:PRINT"PRESS <ESC> TO TERMINATE
UPLOAD AND CLOSE FILE":GOTO71
74 IFFLG(LOG)=ZTHEN72ELSEJ=W:K=FLG(LOG):PRINT:INPUT(L)"Start at Log#
(1)";J:IFJ<WORJ>KTHEN74ELSEINPUT(L)"End at Log#
(End)";K:IFK<JORK>FLG(LOG)THEN74ELSEPRINT"HIT SPACE BAR TO STOP"
75 FORN=JTOK:GET(N):PRINT:PRINT"Log #";N:LOG(S):IFINKEY$=S$THEN71ELSENEXTN
76 GOTO 70
77 IFNOTDTHENPRINT:INPUT(L)"DATA NOT RECOVERED - PROCEED (Y/
N)";D$:GOSUB82:IFD$<>Y$THEN70
78 PRINT:INPUT(L)"RESET DATA MEMORY
(Y)";D$:GOSUB82:IFD$<>Y$THEN70ELSERESET:PRINT:PRINT"RESET DONE":GOTO6
79 PRINT:PRINT"MONITORING - SPACE BAR TO
EXIT":FORY=WTO500:MONIT(W,A,S):IFINKEY$=S$THEN7ELSENEXTY:GOTO7
80 SLEEP*:GOTO7
82 IFD$<>""THENIFASC(D$)>96THEND$=CHR$(ASC(D$)-32)
83 IFD$=Y$THENA=WELSEIFD$="N"THENA=2ELSEA=Z
84 RETURN
85 PRINT:PRINT"TIME:";TAB(Q);TIME$:GOSUB86:PRINT:PRINT"LOGS/
TIMESTAMP:";TAB(Q);C:GOSUB89:PRINT:RETURN
86 IFI>WTHEN87ELSEPRINT"SCAN INTERVAL:";TAB(Q);LEFT$(ZI$,15):RETURN
87 PRINT"BASELINE INTERVAL: ";TAB(Q);LEFT$(ZI$,15):PRINT
88 PRINT"INTERVAL (SEC) - #
SCANS":FORK=WTOX:PRINTP(K);TAB(Q);R(K):NEXT:RETURN
89 PRINT:PRINT"—CHANNEL INFO—
":GOSUB90:PRINT:GOSUB91:PRINT:GOSUB92:PRINT:GOSUB93:PRINT:GOSUB94:RETURN
90 PRINT"SENSOR DESCRIPT:";TAB(Q);Z1$(W);:RETURN
91 PRINT"DISPLAY UNITS:";TAB(Q);Z2$(W);:RETURN
92 PRINT"CONVERSION MULT:";TAB(Q);Z4!(W);:RETURN
93 PRINT"OFFSET:";TAB(Q);Z5!(W);Z2$(W);:RETURN
94 PRINT"WARM-UP (mS):";TAB(Q);Z3%(W);:RETURN
95 A=Z:IFERR=41THENGOSUB101:RESUME
96 PRINTA$,ERL,ERR:IFERR=43THENRESUME7ELSERESUME
97 ONERRORGOTO100:E=F:INPUT(L)"ENTER Month/Day (MM/DD)";M$:M#=CVI(M$)
98 INPUT(L)"ENTER Hour/Min./Sec. (HH/MM/SS)";T$:T$="00/00
```

```
"+MID$(T$,W,2)+":"+MID$(T$,4,2)+":"+MID$(T$,7,2):T#=CVI(T$):T#=M#+T#:T$=MKT$(T#)
99 RETURN
100 IFERR=41THENGOSUB101:RESUMEELSEPRINTA$,ERL,ERR:E=T:RESUME99
101 PRINT:PRINT"* TIMEOUT *":SLEEP*:PRINT:RETURN
 OK
>
```

INTEL HEX FILE SAMPLE

For those users not familiar with the format of an Intel Hex file, a sample file has been provided below. Intel Hex format allows faster uploading of data than other methods and is being used to upload collected data to disk. When loaded from disk into Terravue, the file is then converted to ASCII format.

```
:10000000800701872O0A8E0500202020202020202044
:1000100020202020202020202020202020202020E0
:1000200020202020202020202020200325123620E0
:10003000090325130743057025A00820000000100DE
:1000400081010001003520505349205052455333F
:10005000555245000000004654000000000000064B6
:1000600000CDCC3882CDCCB882000000000000006A
:10007000000000820325123620088300048500005A
:1000800000001000820325123630058300048203 2D
:1000900025123640058300048203251236500583 5D
:0E0580000583000482032512575005830004F2
:00000001FF
```

APPENDIX B - ADVANCED TECHNIQUES

Since users often have different ideas concerning the way data is collected and displayed, it is important to provide a flexible operating environment. This appendix discusses two examples that can expand the capability of the AquiStar: alternative water level referencing and real-time data printout.

REAL-TIME DATA PRINTOUT

As mentioned earlier in this manual, the AquiStar allows for data printout to a parallel printer during data acquisition. In order to produce a hard copy while simultaneously logging to memory, appropriate provisions have to be made *before* starting the logging routine. Take the following steps to prepare for printing:

1. Connect a parallel printer to the LPT1 port of your computer.

2. Work through the set-up menu to configure the AquiStar for the logging routine you wish to perform. *Do not select the **Acquisition** menu yet!*

3. Press <ESC> to exit terminal mode.

4. Exit the **Terracom** menu by pressing <ESC> or selecting the **Quit** option.

5. Press <ESC> or select **Quit** to exit the Terrasys main menu. You should now see a DOS prompt on your screen.

6. Press <CTRL>+<PRTSC>. This will cause your printer to print the information appearing on the screen.

7. Load Terrasys 3.0 by typing **Terra3** at the prompt and choose the **Terminal Emulator** option from the main menu.

8. Select **Terminal Mode** from the **Terracom** menu and wake up the data logger by pressing <SHIFT>+<C>.

9. Select **2-Acquisition** from the main PGM3 menu and choose the menu option appropriate for your test. The test will start, and data will be printed out as it is being displayed on the screen.

   Note If the scanning interval is less than 3 seconds, data will not be printed.

ALTERNATIVE WATER LEVEL REFERENCING

Sometimes it is useful to record the data referenced to some other fixed point, e.g. the water level measured from the top of the well casing. During a pump test, the actual water pressure on the transducer *decreases* as the water level falls, but the distance from the top of the well casing to the water level *increases*.

The logger can be made to record in this manner by changing the conversion multiplier and offset. To accomplish this variation:

1. Determine the transducer depth. This can be done by measuring a length of transducer and cable, marking it with a piece of tape and lowering it into the well. Another way is to measure the static water level from casing top with a commercially available water level indicator. Now, with the data logger in monitor mode (see the **4-Monitor** option in Chapter V) and the pressure transducer connected, lower the sensor and cable down into the well. The monitor routine will display 0.00 ft of water until the transducer reaches the static water level. Continue lowering the transducer to a depth appropriate for its range and the expected drawdown of the well. Secure the cable at the top to insure that the transducer depth does not change. Press the <SPACEBAR> and record the last reading. This will be the transducer submergence depth below the static water level.

2. Subtract the static water level and the transducer submergence depth from the previously calculated offset.

3. Multiply both the conversion multiplier and the new offset by -1 and record these values in the channel information portion of the set-up.

The following diagram is provided to illustrate the two examples below:

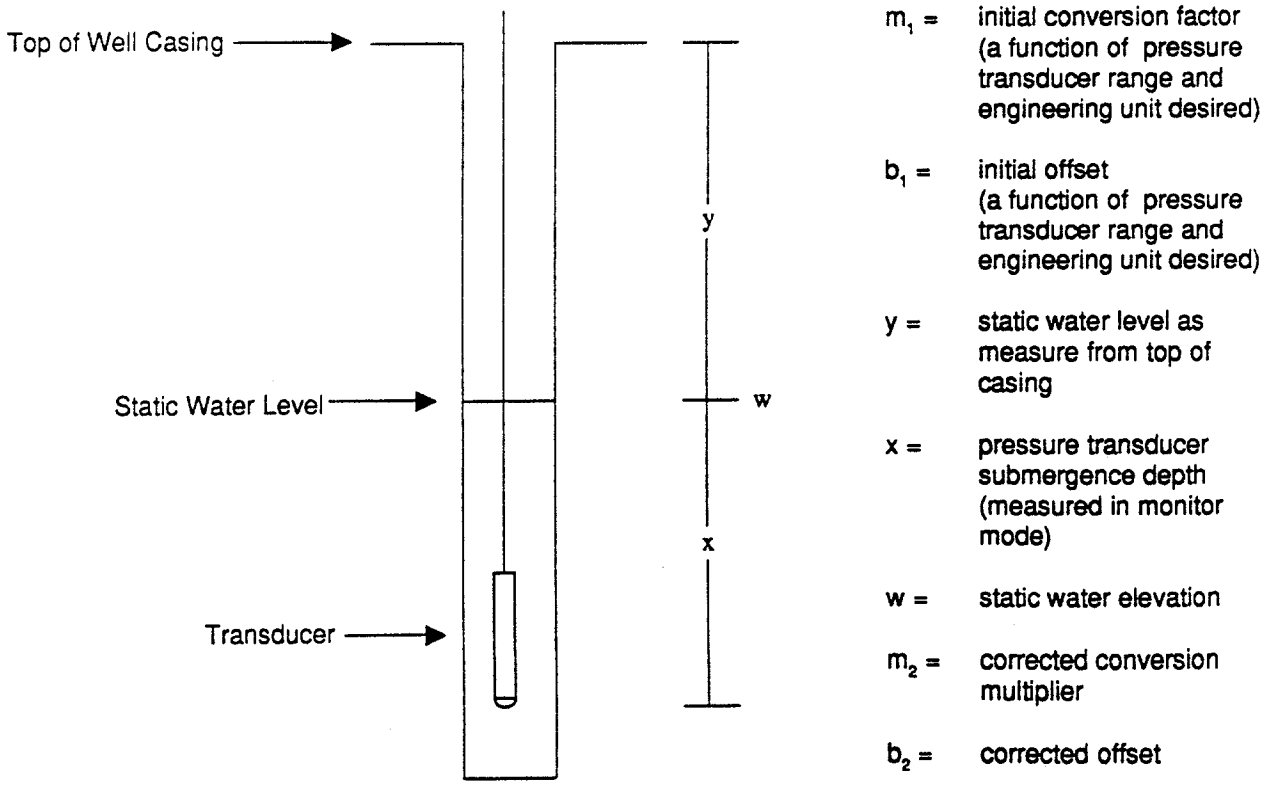

Figure B.1 Alternative Water Level Referencing

EXAMPLE 1 - RECORD STATIC WATER LEVEL FROM CASING TOP

Assume the following conditions:

- 100 psi pressure transducer
- engineering units = ft water
- static water level (y) = 50 ft
- transducer reading in monitor mode (x) = 10 ft

- initial conversion multiplier (m_1) = 57.75
- initial offset (b_1) = -57.75

The new conversion multiplier and offset are then calculated as follows:

New offset: b_2 $= -1(b_1 - y - x)$
$= -1(-57.75 - 50 - 10) = \underline{117.75}$

New conversion multiplier: m_2 $= -1(m_1)$
$= -1(57.75) = \underline{-57.75}$

This configuration may be checked by selecting monitor mode once again. The water level displayed on the screen should now be 50 feet. Raising the transducer should result in an increase on the screen.

EXAMPLE 2 - RECORD WATER LEVEL ELEVATION

Assume the following conditions:

- 20 psi pressure transducer
- engineering units = ft water
- static water level elevation (w) = 94 ft
- transducer reading in monitor mode (x) = 37 ft

- initial conversion multiplier (m_1) = 11.55
- initial offset (b_1) = -11.55

Since static water level elevation decreases with decreasing pressure, the conversion multiplier remains the same.

The new offset is then calculated as follows:

New offset: b_2 $= b_1 + w - x$
$= -11.55 + 94 - 37 = \underline{45.45}$

APPENDIX C - IMPORTING A .PRN FILE INTO LOTUS 1-2-3

In Chapter VI, Working with Terrasys 3.0, you learned how to create a .prn file suitable for import into Lotus 1-2-3 or other spreadsheet programs. To import this file into Lotus 1-2-3, follow the instructions below:

Run the Lotus 1-2-3 program and execute the following commands:

/
File
Import
Numbers

Select or type in the name of the import file, including the drive path if necessary, but do not type in the .prn file extension.

The / F I N command will import the file at the present cursor position in the spreadsheet. It enters each row of characters in the ASCII file into a row in the worksheet. Insure that there is enough room in the worksheet to receive the data; imported data will overwrite existing cell contents. Note also that it may be necessary to expand the column widths in the worksheet from their default value of nine (9) characters, in order to obtain full data resolution. To do so, simply execute a / Worksheet Global Column-Width command and set the width of the worksheet columns to either 15 or 18, depending on the analog-to-digital resolution of your data logger (10 or 12 bit).

The labels in the import file are formatted for a column width of twenty-two (22) characters. Therefore, you must set the first column of the worksheet receiving the import file to a column width of 22 characters by executing the following command:

/
Worksheet
Column
Set-Width

Enter the new column width by typing "22" or pressing -> to expand the column to the necessary width.

The time data will not be in a standard recognizable format but rather in a Lotus compatible format. To convert the date to a standard format, use the Lotus 1-2-3 command

/
Range
Format
Date

and select option 4, Long International Standard.

To convert the time to a standard format, use the Lotus 1-2-3 command

/
Range
Format
Date
Time

and select option 3, Long International Standard.

When graphing an imported Lotus file, use the first column of the timestamp data, i.e. the date column, rather than the time column as the time variable for your X axis. The reason for this lies in the fact that this column contains both the date and time information encoded as a single Lotus 1-2-3 value. In the conversion process, the time information is simply not displayed by the program. The time column only contains the hours:minutes:seconds data encoded as a value; therefore, the time column is not graphable.

INDEX

A

B

C

D

P

Q

R

S

T

U

V

W

Submersible Pressure Transducer

INSTALLATION, MAINTENANCE, AND OPERATIONS MANUAL

Table of Contents

I. Introduction

This manual has been designed to work with the complete PS9000 Series Submersible Pressure Transducers. Please see the specific chapter for your model. These chapters include certain information pertaining to that model. The remainder of this manual describes all basic operating and maintenance instructions. Also note the following before continuing:

> Model PS9000 is a transmitter. All other models are transducers. The terms "Transducer" and "PS9000 Series" will be used to describe all instruments in the general chapters of this manual.

The PS9000 Series Pressure Transducers have been designed to provide trouble-free submersible operation in liquid environments, when properly installed and operated. Please take the time to read through this manual if you are not familiar with this product.

II. Initial Inspection and Handling

Upon receipt of your transducer, inspect the shipping package for damage. If any damage is apparent, note the signs of damage on the appropriate shipping form. After opening the carton, look for concealed damage such as a cut cable. If concealed damage is found, immediately file a claim with the carrier.

Check the etched label on the transducer to be sure that the proper range and type were provided. Also check the label attached to the cable at the connector end for the proper cable length.

III. Do's and Don'ts

Do handle the device with care.
Do store the device in a dry, inside area when not in use.
Do install a desiccant chamber if you are doing long-term outdoor monitoring.

Don't install the device so that the connector end is submerged.
Don't support the device with the connector or with the connectors of an extension cable. Use a strain relief device to take the tension off the connectors.
Don't allow the device to free-fall down a well at high velocities as impact damage can occur.
Don't bang or drop the device on hard objects.
Don't disassemble the device. (The warranty is void if transducer is disassembled.)

IV. General Information

The following paragraphs outline the basics of how pressure is measured using submersible pressure transducers:

Liquids and gasses do not retain a fixed shape. Both have the ability to flow and are often referred to as fluids. One fundamental law for a fluid is that the fluid exerts an equal pressure in all directions at a given level. Further, this pressure increases with an increasing depth of "submergence". If the density of a fluid remains constant (noncompressible...a generally good assumption for water at "normal" pressures and temperatures), this pressure increases linearly with the depth of "submergence".

We are all "submerged" in the atmosphere. As we increase our elevation, the pressure exerted on our bodies decreases as there is less of this fluid above us. It should be noted that atmospheric pressure at a given level does vary with changes in the weather. One standard atmosphere (pressure at sea level on a "normal" day) is defined to be 14.7 PSI.

There are several methods to reference a pressure measurement (see Figure 1). Absolute pressure is measured with respect to an ideal vacuum (no pressure). Gauge pressure is the most common way we express pressure in every day life and is the pressure exerted over and above atmospheric pressure. With this in mind, gauge pressure (Pg) can be expressed as the difference between the absolute pressure (Pa) and atmospheric pressure (Patm):

$$Pg = Pa - Patm$$

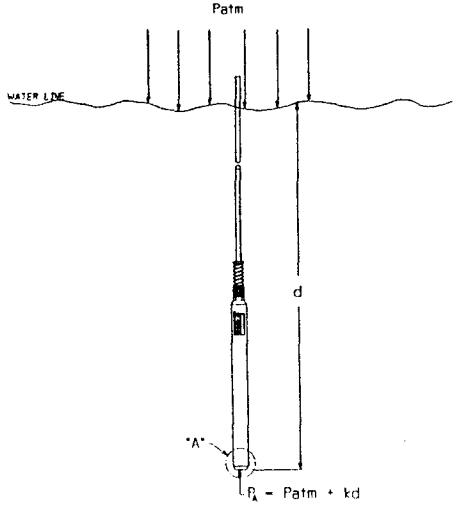

Figure 1. Pressure Diagram

To measure Gauge pressure, atmospheric pressure is subjected to one side of the system and the pressure to be measured is subjected to the other. The result is that the differential (gauge pressure) is measured. A tire pressure gauge is a common example of this type of device.

Recall that as the level of submergence increases (in an incompressible fluid), the pressure increases linearly. Also, recall that changes in weather cause the absolute atmospheric pressure to change. In water, the absolute pressure Pa at some level of depth (d) is given as follows (see Figure 2):

$$Pa = Patm + kd$$

where k is simply a constant (i.e.: 2.307 ft of water = 1 PSI)

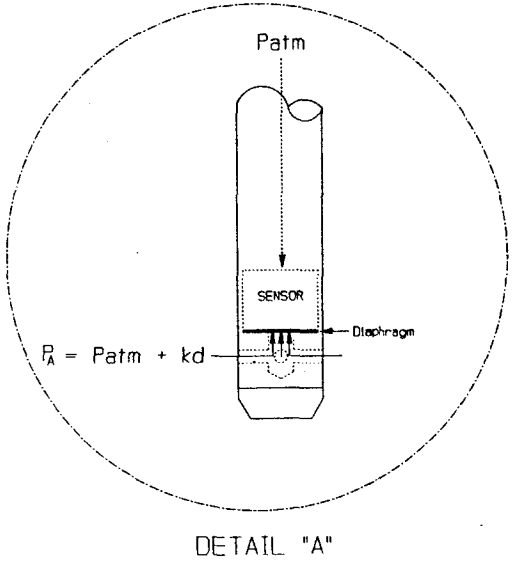

Figure 2. Pressure Diagram, Detail "A"

INW's standard gauge submersible pressure devices utilize a vent tube in the cable to allow the device to reference atmospheric pressure. The resulting gauge pressure measurement reflects only the depth of submergence. That is, the net pressure on the diaphragm (Figure 2) is due entirely to the depth of submergence.

V. Installation

The PS9000 Series measures pressure. The most common application is measuring liquid levels in wells and tanks. In order to do this, the transducer must be installed below the water level at a fixed depth. The installation depth depends on the range of the transducer. One (1) PSI is equal to approximately 2.31 feet of water. If you have a 5 PSI transducer, the range is 11.55 feet of water and the transducer should not be installed at a depth below 11.55 feet. If the transducer is installed below its maximum range, damage may result to the transducer and the output reading will not be correct.

Monitoring Wells

Lower the transducer to the desired depth. Fasten the cable to the well head using tie wraps or a weather proof strain-relief system. When securing the cable, make sure not to pinch the cable too tightly or the vent tube inside the cable jacket may be sealed off. Take a measurement to insure the transducer is not installed below its maximum range. It is recommended that several readings be taken to insure proper operation after installation.

Important Note: If the transducer is to be left in the well for a long-term monitoring application and the connector end is not in a dry, thermally-stable environment, a desiccant chamber must be installed in line with the cable to prevent condensation in the cable vent tube. Water in the vent tube will cause inaccurate readings and, in time, will work its way into the transducer and damage it.

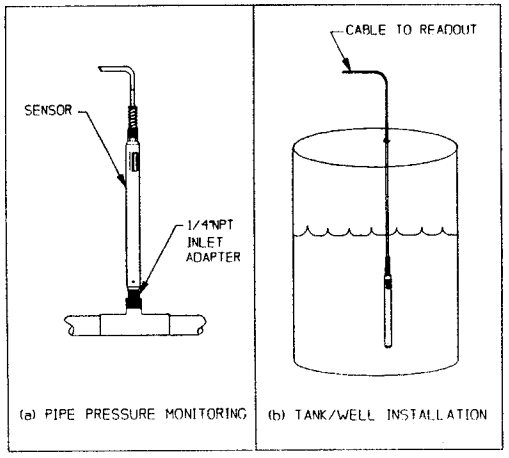

Figure 3: Installation

Other Installations

The transducer can be installed in any position; however, when it leaves the factory it is tested in the vertical position. Strapping the transducer body with tie wraps or tape will not hurt it. INW can provide an optional 1/4" NPT input adapter which is interchangeable with the standard end cone for those applications where it is necessary to directly attach the transducer to a pipe, tank or other pipe port (see Figure 3). If the transducer is being installed in a fluid environment other than water, be sure to check the compatibility of the fluid with the wetted parts of the transducer. INW can provide a variety of seal materials if you are planning to install the transducer in an environment other than water.

VI. Maintenance

INW recommends that the transducer be returned for factory recalibration and check-up every one to two years or if problems develop with sensor stability or accuracy. If the transducers have been exposed to hazardous materials, do not return them without notification and authorization. INW will ask that if the transducer assembly has been exposed to hazardous or toxic chemicals, you send back only the transducer and end connector, discarding the cable.

Transducer - all models: There are no user-serviceable parts.

Cable: Cable can be damaged by abrasion, sharp objects, twisting, crimping or crushing and pulling. Take care during installation and use to avoid cable damage. If a section of cable is damaged, it is recommended that you send your sensor back to replace the cable harness assembly.

End Connections: The contact areas (pins & sockets) of Mil-spec connectors will wear out with extensive use. If your application requires repeated connections (in excess of 5000 connections) other types of connectors can be provided. The connectors INW uses are not submersible, but are designed to be splash-resistant.

Desiccant Chambers: Inspect the Desiccant Chamber at least once every two months. Inside the chamber is a moisture indicator (a small capsule -- see Figure 4). If this has turned pink or white the desiccant and moisture indicator need to be replaced. Pull out the side plug, remove the moisture indicator from the inside chamber and the white cylindrical desiccant holder from the side plug and discard. Refills can be purchased from Instrumentation Northwest.

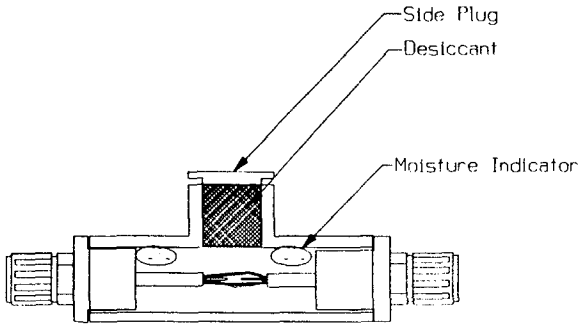

Figure 4. Desiccant Chamber

VII. Troubleshooting

Erratic Readings

Erratic readings can be caused by a damaged transducer, damaged cable, poor connections or improper operation of readout equipment. In most cases, erratic readings are due to moisture getting into the system. Assuming that the readout equipment is working correctly, the first thing to check is the connection. Look for moisture between contacts or a loose or broken wire. If the connection appears OK, pull the transducer up a known distance while monitoring its output. If the transducer responds approximately as it should, but the reading is still erratic, most likely the cable is damaged. If the transducer does not respond approximately as it should, it is most likely that the sensor is damaged. In either case, consult the factory.

Oscillating Readings Over Time

If, after time, your transducer is functioning normally but your data is showing a cyclic effect in the absence of water level changes, you are probably seeing barometric changes. The amount is usually .5 to 1.5 feet of water. This can be caused by a plugged vent tube in the cable or time delays in water level changes in the aquifer itself. Time delays are caused in tight formations where the transducer will immediately pick up barometric changes but the aquifer will not. If you think you are having this type of problem you will have to record the barometric pressure as well as the water level pressure and compensate the data. If it appears that the vent tube is plugged, consult the factory.

If a desiccant chamber is not installed in line with the cable, water may have condensed in your vent tube causing it to plug. After you are finished installing the chamber you can test the vent tube by applying a small amount of pressure to the side of the desiccant chamber and seeing if this affects the transducer reading.

Zero Readings When Pressurized

Continuous zero readings are caused by an open circuit which usually indicates broken cable, a bad connection, or possibly a damaged transducer. Check the connector to see if a wire has become loose, or if the cable has been cut. If neither of these appears to cause the problem, the transducer needs factory repair.

VIII. LIMITED WARRANTY/DISCLAIMER - PS9000 SERIES SUBMERSIBLE PRESSURE TRANSDUCERS

A. Seller warrants that products manufactured by Seller when properly installed, used and maintained **with a properly installed desiccant pack,** shall be free from defects in material and workmanship. Seller's obligation under this warranty shall be limited to replacing or repairing the part or parts or, at Seller's option, the products which prove defective in material or workmanship within ONE (1) year from the date of delivery, provided that Buyer gives Seller prompt notice of any defect or failure and satisfactory proof thereof. Any defective part or parts must be returned to Seller's factory or to an authorized service center for inspection. Buyer will prepay all freight charges to return any products to Seller's factory, or any other repair facility designated by Seller. Seller will deliver replacements for defective products to Buyer (ground freight prepaid) to the destination provided in the original order. Products returned to Seller for which Seller provides replacement under this warranty shall become the property of Seller.

This limited warranty does not apply to lack of performance caused by abrasive materials, corrosion due to aggressive fluids, mishandling or misapplication. Seller's obligations under this warranty shall not apply to any product which (a) is normally consumed in operation, or (b) has a normal life inherently shorter than the warranty period stated herein.

In the event that equipment is altered or repaired by the Buyer without prior written approval by the Seller, all warranties are void. Equipment and accessories not manufactured by the Seller are warranted only to the extent of and by the original manufacturer's warranty.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, WHETHER ORAL, WRITTEN, EXPRESSED, IMPLIED OR STATUTORY. IMPLIED WARRANTIES OF FITNESS AND MERCHANTABILITY SHALL NOT APPLY. SELLER'S WARRANTY OBLIGATIONS AND BUYER'S REMEDIES THEREUNDER (EXCEPT AS TO TITLE) ARE SOLELY AND EXCLUSIVELY AS STATED HEREIN. IN NO CASE WILL SELLER BE LIABLE FOR CONSEQUENTIAL DAMAGES. LABOR PERFORMED IN CONNECTION WITH REMOVAL AND REPLACEMENT OF THE SENSOR SYSTEM, LOSS OF PRODUCTION OR ANY OTHER LOSS INCURRED BECAUSE OF INTERRUPTION OF SERVICE. A NEW WARRANTY PERIOD SHALL NOT BE ESTABLISHED FOR

REPAIRED OR REPLACED MATERIAL, PRODUCTS OR SUPPLIES. SUCH ITEMS SHALL REMAIN UNDER WARRANTY ONLY FOR THE REMAINDER OF THE WARRANTY PERIOD ON THE ORIGINAL MATERIALS, PRODUCTS OR SUPPLIES.

B. With respect to products purchased by consumers in the United States for personal use, the implied warranties including but not limited to the warranties of merchantability and fitness for a particular purpose, are limited to twelve (12) months from the date of delivery.

Some states do not allow limitations on the duration of an implied warranty, so the above limitation may not apply to you. Similarly, some states do not allow the exclusion or limitation of consequential damages, so the above limitation or exclusion may not apply to you. This limited warranty gives you specific legal rights; however, you may also have other rights which may vary from state to state.

IX. Transducer Component and Wiring Information

The following is a diagram of the transducer components. The list below specifies wiring information for each transducers.

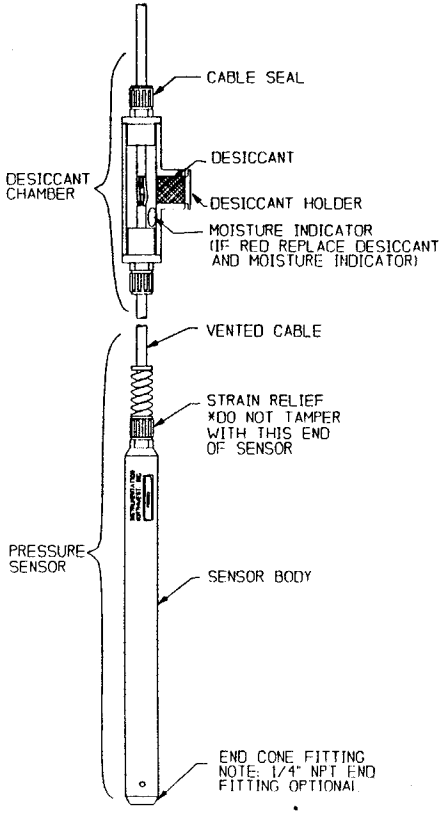

Figure 5. Transducer Components

PS9000 wiring information:
Cable type: 2-conductor, vented

Blue	=	- excitation
White	=	+ excitation

PS9001 wiring information
Cable type: 6-conductor, vented (normally only 3 used)

Red	=	+ excitation
Black	=	- excitation
Orange	=	output

PS9102 wiring information
Cable type: 6-conductor, vented

Black	=	+ excitation
Yellow	=	- excitation
Orange	=	+ power sense
White	=	- power sense
Red	=	+ output
Brown	=	- output

PS9104 wiring information
Cable type: 6-conductor, vented

Black	=	+ excitation
Yellow	=	- excitation
Orange	=	+ power sense
White	=	- power sense
Red	=	+ output
Brown	=	- output

X. PS9000 4-20 mA Transmitter

The PS9000 pressure transmitter is a two-wire, 4-20 mA current loop device. Operation requires 9-24 VDC excitation and stability of the device will be reached less than 100 ms after power is applied.

As mentioned above, the PS9000 transmitter is a current loop device. This means that changes in pressure imposed on the stainless steel diaphragm result in proportional changes in current. The excitation source (DC supply or data logger) supplies the power but the transmitter actually controls how much current flows as long as the excitation specifications (e.g., voltage level) are met.

For a standard gauge pressure device, there is zero pressure on the diaphragm when above the surface of the liquid. This zero pressure is converted to a current flow of 4 mA. As the transducer is lowered into the liquid, the amount of current that flows increases linearly (with increasing depth) to 20 mA when the maximum rated pressure (thus depth) is reached. That is, there is a straight line relationship between pressure (thus depth of submergence) and the amount of current that flows. A data logger therefore can apply power, measure the amount of current that is flowing and convert that to the depth submergence using a multiplier and offset (m and b, respectively, for a y = mx + b straight line) which are preset in the logger by the user.

There are a number of differences in regards to data loggers. However, in most data loggers, the current that flows is converted to a voltage which is measured. The multiplier and offset operate on this measured voltage to provide desired units. For INW's AquiStar data loggers DL-1, DL-1A, and DL-4A through DL-16A, the multiplier and offset can be calculated as follows:

M = Pmax./4
b = -Pmax./4

Where Pmax is the rated range of the transmitter. This can be in PSI or in feet of water (1 PSI is approximately equal to 2.31 feet of water).

Electrical Specifications

Linearity/Repeatability/Hysteresis*:	max. ±0.25% FSO	typ. ±0.1% FSO
Zero Offset Accuracy (20°C):	max. ±0.5% FSO	
Sensitivity Accuracy (20°C):	max. ±0.25% FSO	typ ±0.125% FSO
Power Supply Sensitivity:	max. 0.3% FSO	
Temperature Error:	max. ±2.0% FSO	typ. ±0.7% FSO
Thermal Hysteresis:	the output will typically return to within ±0.25% FSO of its initial reading subsequent to one full cycle over the compensated temperature range.	
Transmitter Voltage:	9-24 VDC	
Compensated Temperature Range:	0-50°C	
Operating Temperature Range:	-5°C to +70°C	

**best fit straight line*

If you did not purchase a connector with your transducer, please see Chapter IX. Transducer Component and Wiring Information.

Mechanical Specifications

Transmitter --	
Length:	9.125"
O.D.:	0.840"
Body Material:	304 stainless steel
Wire Seal Material:	Viton/Buna-N
Diaphragm:	316 stainless steel
Desiccant Pack:	available
Terminating Connector:	available
Cable --	
O.D.:	max. 0.28"
Cable Jacket:	Polyurethane
Conductor Type:	2-conductor, vented
Vent Tube:	Nylon
Break Strength:	138 lbs.
Maximum Length:	2000 ft.

XI. PS9001 0.1 - 5.1 V Transducer

The PS9001 pressure transducer is a three-wire 0.1 to 5.1 V device. Operation requires 9-24 VDC excitation and stability of the device will be reached less than 100 ms after power is applied.

As mentioned above, the PS9001 transducer is a three-wire 0.1 to 5.1 V device. There are two leads which are used to power the transducer. The pressure imposed on the stainless steel diaphragm is converted to a voltage which is measured between the third and negative power leads. As long as the excitation specifications (e.g., voltage level) are met, the PS9001 will adjust the output voltage to correspond to the pressure (thus depth of submergence) seen by the device.

For a standard gauge pressure device, there is zero pressure on the diaphragm when above the surface of the liquid. This zero pressure is converted to an output voltage of 0.1 V. As the transducer is lowered into the liquid, the output voltage increases linearly (with increasing depth) to 5.1 V when the maximum rated pressure (thus depth) is reached. That is, there is a straight line relationship between pressure (thus depth of submergence) and the output voltage. A data logger therefore can apply power, measure the output voltage and convert the reading to the depth submergence using a multiplier and offset (m and b, respectively, for a y = mx + b straight line) which are preset in the device by the user.

Electrical Specifications

Linearity/Repeatability/Hysteresis*:	max. ±0.25% FSO	typ. ±0.1% FSO
Zero Offset Accuracy (20°C):	max. ±0.5% FSO	
Sensitivity Accuracy (20°C):	max. ±0.25% FSO	typ ±0.125% FSO
Transducer Voltage:	9-24 VDC	
Operating Temperature Range:	-5°C to +70°C	

**best fit straight line*

If you did not purchase a connector with your transducer, please see Chapter IX. Transducer Component and Wiring Information.

Mechanical Specifications

Transducer --	
Length:	9.125"
O.D.:	0.840"
Body Material:	304 stainless steel
Wire Seal Material:	Viton/Buna-N
Diaphragm:	316 stainless steel
Desiccant Pack:	available
Terminating Connector:	available
Cable --	
O.D.:	max. 0.28"
Cable Jacket:	Polyurethane
Conductor Type:	6-conductor, vented
Vent Tube:	Nylon
Break Strength:	138 lbs.

XII. PS9102 Active mV Transducer

The PS9102 is a ratiometric, differential output transducer from which a four or six wire measurement can be made. Active circuitry is present so the device may only be powered in one polarity. Shunt protection is provided within the device. The cable utilized contains six conductors but only four are commonly used. Note that the unused conductors are connected to the + and - power at the transducer so care must be exercised in the termination of these conductors.

There are two conductors utilized to power the device (+/- excitation) and two conductors for the output signal. The output signal is a voltage (mV) measured between the two output conductors which is the same as measuring each output conductor with respect to negative excitation ($Vo^+ - Vo^-$ = the output signal). The output signal is

referred to as differential. The PS9102 is a ratiometric device as the output signal is proportional to the excitation level.

The additional two conductors are tied to positive and negative excitation at the transducer. These conductors can be utilized to measure the excitation at the transducer. The cable used by Instrumentation Northwest, Inc. has a resistance of approximately 0.026 Ohm/ft with a typical temperature coefficient of $100 * 10^{-6}$ ohms/(ft * °C).

The PS9102 transducer requires a two point calibration. This is due to the nature of the device: the output signal is derived directly from the output of the bridge. Instrumentation Northwest, Inc. provides a calibration sheet with each device giving output characteristic data at room temperature. In addition, Instrumentation Northwest, Inc. maintains a calibration log which contains this data.

For a standard gauge pressure device, there is zero pressure on the diaphragm when above the surface of the liquid and the offset for a typical device is about 1 mV. As the transducer is lowered into the liquid, the output voltage increases linearly (with increasing depth). That is, there is a straight line relationship between pressure (thus depth of submergence) and the output voltage. Typically, PS9102 devices will have an output span of 5 to 6 mV per volt of excitation (about 27 mV for 5 V excitation). A data logger therefore can apply power, measure the output voltage and convert the reading to the depth of submergence using a multiplier and offset (m and b, respectively, for the formula y = mx + b straight line) which are preset in the device by the user.

Electrical Specifications

Linearity/Repeatability/Hysteresis*:	max. ±0.25% FSO	typ. ±0.1% FSO
Sensitivity:	typ (5-6) mV/V ratiometric	
Zero Offset:	max. ±3 mV	
Common Mode Voltage:	typ. Vi/2	
Thermal Hysteresis:	the output will typically return to within ±0.25% FSO of its initial reading subsequent to one full cycle over the compensated temperature range.	
Transducer Voltage:	5-14 VDC (ratiometric, shunt protected)	
Temperature Error (0-50°C)	max. ± 2% FSO	
Compensated Temperature Range:	0-50°C	
Operating Temperature Range:	-5°C to +70°C	

**best fit straight line*

If you did not purchase a connector with your transducer, please see Chapter IX. Transducer Component and Wiring Information.

Mechanical Specifications

Transducer--	
Length:	9.125"
O.D.:	0.840"
Body Material:	304 stainless steel
Wire Seal Material:	Viton/Buna-N
Diaphragm:	316 stainless steel
Desiccant Pack:	available
Terminating Connector:	available
Cable--	
O.D.:	max. 0.28"
Cable Jacket:	Polyurethane
Conductor Type:	6-conductor, vented
Vent Tube:	Nylon
Break Strength:	typ. 138 lbs.

XIII. PS9104 Passive mV Transducer

The PS9104 is a ratiometric, differential output transducer. This device has been specifically designed to be operated in the 2.5 V excitation region. The output voltage is to be normalized to the excitation current using a precision series resistor at the data logger. This measurement technique is the counterpart of the 6 wire full bridge measurement where the output voltage is normalized to the bridge voltage.

Two conductors are provided for excitation of the device. The precision resistor is to be placed in series with the transducer in the excitation scheme. The excitation current is determined by measuring the voltage drop across the precision resistor (I = V/R). The output voltage is measured between the Vo+ and Vo- leads. After these two voltages are measured, the ratio of the output voltage to excitation current (dimension Ohms) is calculated and this result may then be scaled to the desired units. The two additional conductors are connected to the excitation leads at the transducer. Care must be taken in terminating these conductors.

The PS9104 transducer requires a two point calibration. This is due to the nature of the device: the output signal is derived directly from the output of the bridge. Instrumentation Northwest, Inc. provides a calibration sheet with each device giving output characteristic data at room temperature. In addition, Instrumentation Northwest, Inc. maintains a calibration log which contains this data. Calibration can also be accomplished using known depths and output data measured in the field. It is advisable to use depths as close as possible to the rated span of the device.

For a standard gauge pressure device, there is zero pressure on the diaphragm when above the surface of the liquid. The magnitude of the offset for a typical device is about 1 mV. As the transducer is lowered into the liquid, the output voltage increases linearly (with increasing depth and a constant voltage applied). Typically, PS9104 devices will have differential output voltage spans of about 15 mV per volt of excitation (about 37 mV at maximum pressure for 2.5 V across the bridge).

Electrical Specifications

Linearity/Repeatability/Hysteresis*:	max. ±0.25% FSO typ. ±0.1% FSO
Sensitivity:	typ. 15-16 mV/V (ratiometric)
Zero Offset:	max. ±3 mV
Common Mode Voltage:	typ. Vi/2
Thermal Hysteresis:	the output will typically return to within ±0.25% FSO of its initial reading subsequent to one full cycle over the compensated temperature range.
Transducer Voltage:	typ. 2.5 V
Temperature Error (0-50°C)**	max. ± 2% FSO
Compensated Temperature Range:	0-50°C
Operating Temperature Range:	-5°C to +70°C

**best fit straight line*
***output normalized to excitation current*

If you did not purchase a connector with your transducer, please see Chapter IX. Transducer Component and Wiring Information.

Mechanical Specifications

Transducer--	
Length:	9.125"
O.D.:	0.840"
Body Material:	304 stainless steel
Wire Seal Material:	Viton/Buna-N
Diaphragm:	316 stainless steel
Desiccant Pack:	available
Terminating Connector:	available
Cable--	
O.D.:	max. 0.28"
Cable Jacket:	Polyurethane
Conductor Type:	6-conductor, vented
Vent Tube:	Nylon
Break Strength:	typ. 138 lbs.

XIV. Reordering Information

For replacement parts, service, or accessories, please contact:

Instrumentation Northwest, Inc.
14972 NE 31st Circle
Redmond, WA 98052
(206) 885-3729 · FAX (206) 867-0404

Notes